The Environmental Ethics of the Corporatization of Agriculture and Crop Genetic Engineering

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Abstract

The corporatization of agriculture has resulted in significant implications for the environment and consequently environmental management. In particular, corporate application of genetic engineering (GE) has resulted in increased and unnecessary environmental risks through inappropriate applications of GE and increased pesticide use. GE technology has in turn allowed for the agriculture industry to become further corporatized. Current environmental management procedures with regard to risk assessment and the regulatory processes of GE crops have proven inadequate in light of such corporate involvement.

The research aim of this thesis was to establish whether the corporatization of agriculture, and the consequent corporate application of GE crops, results in breaches of environmental ethics, as defined by the worldviews of biocentrism and ecocentrism. This aim was achieved through the application of a structured literature review, using an interpretive approach within the paradigm of hermeneutics. The literature analysis was carried out on peer-reviewed journal articles from the last 10 year period, within which selected articles were asked a series of interview questions in order to fulfil the research objectives, and consequently the aim. The extracted information was critically considered within the framework of environmental ethics and the contrasting worldviews of anthropocentrism, technocentrism, biocentrism and ecocentrism.

The key issue identified was the lack of consideration of biocentric and ecocentric values in the arguments made by corporations and proponents of GE crops as a result of a dominance of anthropocentric and technocentric worldviews. The lack of such values on the part of corporations ensures that both sides of the debate are arguing from different perspectives and as such it seems unlikely that they will ever be able to reach a resolution. This thesis concludes that for progress to be made in the debate on GE agriculture and corporatization, and for appropriate precaution to be employed with regard to risk assessment, the worldview held by agrochemical corporations and proponents of GE needs to shift towards a biocentric and ecocentric understanding of the environment. However, as a complete shift of worldviews on the part of corporations is unlikely, this thesis recommends that attention be shifted away from the polarized controversy in favour of a discussion on coexistence.

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Chapter 1 Introduction

1.1.Thesis Introduction

The increasingly dominant role that multinational corporations have assumed over many areas of human life raises significant ethical questions and implications for environmental management. In particular, large agro-chemical corporations such as Monsanto Company (hereafter referred to as Monsanto) have an unchallenged monopoly over the inputs for commercial crop farms in many countries as a result of patented transgenic seeds and their associated synthetic pesticides and fertilizers. Such corporate dominance has resulted in the loss of smallholder, traditional, mixed farming systems, and the growth of large monocrops which are dependent on increasing quantities of water and synthetic chemical inputs.

In this thesis I argue that genetic engineering (GE) has served as a tool for the corporatization of agriculture, that corporatization has intensified and inappropriately influenced the application of GE in crop agriculture, and that such corporatization, whether by itself or together with the implementation of GE, violates the environmental ethics presented by the biocentric and ecocentric worldviews. The conceptual framework used to demonstrate this argument is based on the contrasting worldviews of anthropocentrism, technocentrism, biocentrism and ecocentrism. Consequently, this thesis argues that the environmental issues surrounding GE and the corporatization of agriculture have originated as a result of anthropocentric and technocentric world views, and that a shift towards biocentric and ecocentric worldviews is essential in order to resolve the controversy and avoid further breaches of environmental ethics.

1.2. Problem

The ethical underpinnings of corporations are fundamentally different to those of environmental managers, being focussed on the generation of profit over environmental sustainability. The lack of certain environmental values in corporations results in the negative environmental implications of corporatized agriculture, specifically through the corporate application of genetically engineered (GE) crops and their associated pesticides. As multinational corporations such as Monsanto increase their monopoly on the agricultural industry, the negative implications for environmental management increase, for example, issues surround contamination of wild ecosystems or non-GE crops with transgenes, loss of biodiversity and the increasing amounts of water and pesticides that are necessary for GE crops to reach their desired yield.

1.3. Aim

The aim of this thesis is to establish whether the corporatization of agriculture, and the consequent corporate application of GE crops results in breaches of environmental ethics, as defined by the worldviews of biocentrism and ecocentrism, according to recent peer reviewed literature.

1.4. Objectives and Working Concepts

The objectives used to achieve the research aim are as follows:

1. Establish the level of environmental risk associated with GE crops through identifying the concerns raised.

2.Establish the implications of crop GE for the environment and the consequent implications for environmental ethics as a result of such risk.

3. Establish the degree to which agriculture has been corporatized and the implications of such corporatization on the environment, significantly, through the corporate application of GE and compromises to the risk assessment process.

4. Establish the degree to which corporatization and the corporate application of GE can be explained by the world views of anthropocentrism and technocentrism, the benefits to be had from incorporating biocentric and ecocentric values, and the likelihood of such inclusion.

Four key working concepts were identified in the initial background literature review and used to organise the literature analysis so that the research objectives could be appropriately addressed. They are:

1) environmental ethics of GE;
2) environmental ethics of corporatization;
3) risk assessment; and
4) corporate social responsibility.

1.5. Environmental Ethics Framework

Environmental Ethics and the world views of anthropocentrism, technocentrism, biocentrism and ecocentrism will serve as the conceptual framework for analysing the above research objectives. The study of ethics is defined as “an inquiry that proceeds through the rational and critical examination of the reasons, arguments, and theories that can be given to show that one type of behaviour is morally right or that another is morally wrong” (Velasquez & Rostankowski, 1985). Environmental ethics applies this study to “human interactions with and impacts on” the environment, which is in turn defined as an “objective encompassing

system of nature" (Attfield, 2014, p.14). It must be acknowledged that environments free of human impact no longer exist. Consequently, when this thesis refers to the environment (the aforementioned "system of nature") it refers to the environment as a whole, including both wild and agricultural ecosystems. I believe that it is pertinent to apply environmental ethics to all ecosystems, with regard to their resilience and health, as such health contributes to environmental sustainability as a whole due to the inherent interconnectedness and systemic nature of the environment.

Intrinsic value plays a central role in the framework used. It is the value that is ascribed to living beings, ecosystems and landscapes irrespective of their benefits to humans as a result of having a good of their own (Verhoog, 2007). When intrinsic value is ascribed to an organism, species or system, it is then acknowledged that that organism, species or system has an optimum state that should not be compromised by human interference (Attfield, 2013). Such optimum states are usually described with regard to biological integrity, the ability to flourish, ecosystem health and biodiversity. Consequently, for the purpose of this thesis, a breach of environmental ethics consists of anything that compromises the integrity or ability to flourish of an ecosystem, species, or living organism in the present time, or which has the potential to cause such harm in the future.

Anthropocentrism, biocentrism and ecocentrism are values-theories commonly known as worldviews within environmental ethics which describe different environmental perspectives based on the allocation of intrinsic value. Anthropocentrism ascribe humans intrinsic value and hence a hierarchy over the environment. Biocentrism and ecocentrism typically place humans and the environment on an even playing field, attributing intrinsic value to all living organisms. The anthropocentric versus ecocentric understanding of human relations with the environment has been a part of environmental ethics discussion since 1990 (Thompson & Barton, 1994). Consequently, the application of such worldviews to environmental issues is not new. However, the specific application of these contrasting worldviews to the corporatization of agriculture and the corporate application of GE, is something that could benefit from further attention, specifically with regard to risk assessment within environmental management.

Technocentrism adds a further dimension to the analysis. While not being strictly an environmental ethics theory, from the point of view of this thesis, the concept goes hand in hand with anthropocentrism as a worldview that starkly contrasts with biocentrism and ecocentrism. The contrasts between technocentrism and ecocentrism were also being used in the 1990s to frame sustainability issues, and as such, the inherently technocentric

approach of organizational management theory has long been recognized (Gladwin, Kennelly & Krause, 1995). In particular, many have noted the disconnect between management theory and the environment, and the resulting dualism that exists (Gladwin et al., 1995). A similar disconnect and state of dualism exists in anthropocentrism (Purser, Park & Montuori,1995). Consequently, anthropocentrism and technocentrism are argued here to be the worldviews that best describe corporations as a result of the priority given to human benefit and profit over the environmental consequences of corporate practice (eg. Gladwin et al.,1995; Dobson, 1995). In particular, technocentrism has specific relevance for this thesis as it is the worldview that perhaps best represents the approach of corporations with regard to the use of GE technology.

Though the paradigms of anthropocentrism, technocentrism, biocentrism and ecocentrism are not exclusively considered to be worldviews by some, but genres of worldviews due to the different forms that exist within (Attfield, 2013), in this thesis they will be referred to as worldviews with regard to the understanding presented by Norton (1991, p.75 as cited in Gladwin et al., 1995, p.880) as “the constellations of beliefs, values and concepts that give shape and meaning to the world a person experiences and acts within”. These four worldviews have significant impacts on how the environmental ethics of the corporatization of agriculture and GE are understood, and consequently significant implications for environmental management. Many agree that in order for the appropriate respect to be attributed to the environment and for negative consequences of human activity to be avoided, anthropocentric and technocentric world views must transition to more biocentric and ecocentric perspectives (Myhr, 2010b; Purser et al.,1995; Mikkelson & Chapman, 2014; Gladwin et al. 1995). The characteristics of each worldview will be described in more detail in the following chapter.

1.6. Importance

This thesis has significant implications for highlighting the inadequacy of current risk assessment and regulatory procedures in environmental management with regard to the corporate application of GE crops. Aspects of the issue have been well addressed within the literature. Much has been done regarding the socioeconomic and socioethical consequences of GE, and the socioeconomic and socioethical consequences of the corporate control of GE. For example, there is a significant body of literature addressing the implications of biotechnology patents and the associated restrictions to seed saving. However, there is room for a greater investigation of the environmental implications in isolation from the social. Similarly, much of the literature on the risk of GE crops focuses on the human health risks of

ingestion and pesticide application, while environmental risks are mostly noted in passing. This may simply be because human health will usually rank higher in the general population's list of concerns than environmental issues, so stronger arguments can be made both for and against the technology when human health implications are referred to. However, the environmental implications need to be given a higher priority for the long term environmental sustainability of agricultural practices to be ensured.

There is also room for greater clarity regarding the environmental implications of the corporatization of agriculture in isolation from GE technology in order to ascertain whether the primary issue is the technology itself or the corporate application of it. Furthermore, though the link has been made, GE has not explicitly been described as a tool for the corporatization of agriculture in recent literature. Given the significant impacts of GE in combination with the corporatization of agriculture on the environment, the link is one that arguably needs greater attention. Much of the controversy surrounding GE and the role of corporations confuses the roles of each. Consequently, this thesis will highlight the importance of considering the two separately, and isolating the role that corporate application of GE plays in the controversy.

Finally, while anthropocentrism, biocentrism and ecocentrism have been used to help explain different attitudes towards GE, technocentrism has rarely been included in such arguments and could serve to aid in understanding the persistence and polarity of the debate between proponents and opponents of GE agriculture. It may be that the technical nature of GE has resulted in the unwritten assumption that proponents of GE are technocentric by nature, however, the phrase technocentric has not been explicitly used in recent literature to explain a propensity towards favouring GE over traditional agriculture.

All of the abovementioned concepts have significant implications for environmental management, particularly with regard to the risk assessment process for GE crops, and with regard to any possibility of coexistence between GE and traditional agriculture.

1.7. Limitations and Scope

The literature analysis consisted of peer-reviewed journal articles from the last 10 years. Consequently, there were minor limitations associated with the use of secondary data, and the exclusion of non-peer reviewed journal articles or articles older than 10 years. However, these limitations were insignificant when compared to the benefits of framing the research

question within current literature and hence establishing the degree to which certain issues need be revisited.

The scope of this thesis is restricted to the environmental ethics of crop GE and the corporatization of agriculture, excluding any socioeconomic implications, or GE applications outside of agricultural crops. The global scope applied to the thesis is necessary due to the global nature of the issues at hand (environmental degradation and climate change) and the transnational nature of the corporations in question. For example, Monsanto, based in the U.S.A., now has strongholds over the agriculture industries of Argentina and India.

1.8. Thesis Outline

Chapter 1) **Thesis Introduction**

Chapter 1 Introduces the research aim and objectives, and the environmental ethics framework.

Chapter 2) **Background**

This chapter consists of the background literature review that was carried out prior to the research analysis in order to establish and understand the basic concepts involved in the corporatization of agriculture and crop GE. The working concepts listed above emerged as a result of this background literature review and were used in the research analysis. The most common arguments used in favour of and against both GE technology and corporatized agriculture are identified and explained.

Chapter 3) **Methodology**

Chapter 3 explains the methodology used to explore the research aim within the literature analysis, the steps that were carried out and the advantages and limitations involved.

Chapter 4) **Results**

Chapter 4 presents the results of the literature analysis and the consequent analysis of the selected literature.

Chapter 5) **Discussion**

This chapter dicusses the results from Chapter 4 within the framework of the environmental ethics theories of anthropocentrism, technocentrism, biocentrism and ecocentrism.

Chapter 6) **Conclusion**

The conclusion summarises the key points established from the results and discussion chapters with regard to their significance for environmental management and future research.

Chapter 2 Background

2.1. Introduction

The aim of this thesis is to establish whether the corporatization of agriculture, and the consequent corporate application of GE crops, results in breaches of environmental ethics, as defined by the worldviews of biocentrism and ecocentrism. In order to achieve this and consequently the research objectives, a sound understanding of background information was necessary. For example, an understanding of GE technology was necessary to approach the issue of risk and the environmental implications of GE crops. Similarly, the extent that agriculture has become corporatized, and the influence of this corporatization on agricultural practice needed to be established in order to consider the implications of this corporatization on the environment. Finally, the role that things such as pesticides and seed patents play in the relationship between the corporatization of agriculture and corporate application of GE is significant. It is also important to identify the key arguments used by proponents and opponents of GE technology to defend or criticize GE crops respectively. The debate surrounding yield is significant in this. In introducing these ideas, this chapter provides the background information within which the four working concepts were identified:

1) environmental ethics of GE;
2) environmental ethics of corporatization;
3) risk assessment; and
4) corporate social responsibility.

2.2. GE Crops, the Risk and the Controversy

2.2.1 GE crops

GE is the "the direct, intentional alteration of the genetic material of organisms" (Reiss & Straughan, 1996, p.11) through the insertion of a foreign gene, or genes, into a host genome in order for the selected foreign trait to be expressed or existing traits to be altered (Marchant & Marchant, 1999). While the term genetically modified organism (GMO) is also commonly used to refer to GE organisms, the term contains a greater ambiguity with regard to other sources of gene modification, such as selective breeding. In this thesis GE will be the primary term used unless quoted by a secondary source.

The two commonly used methods of inserting foreign genes into the recipient genome are via *Agrobacterium*, which have the biological ability to splice the host DNA and insert small lengths of foreign DNA, or Biolistic gene delivery, also known as the gene gun, which fires gold coated DNA molecules at plant cells in an agar plate (Marchant & Marchant, 1999).

Research is ongoing with new methods being developed and tested such as the manipulation and shuffling of photosynthetic genes, and single base mutations (Waters & Pajerowska-Mukhtar, 2012). However, the basic techniques, as described above, consist of the arrival of foreign genes to a random, unpredictable location on the host genome, (Smith, 2003).

There are currently 179.7 million hectares of land planted with GE crops worldwide (Robaey, 2016b, p.768) having increased by more than 100-fold since their introduction in the mid-1990s (Bennett, Chi-Ham, Barrows, Sexton & Zilberman, 2013). The most common applications of GE in crop agriculture are herbicide resistant crops such as Monsanto's Roundup-ready© (RR) (glyphosate resistant) varieties, and Bt varieties that produce their own insecticidal proteins known as *Cry toxins* from the bacterium *Bacillus thuringiensis* (Bt) (Waters & Pajerowska-Mukhtar, 2012). Roundup© is Monsanto's branded herbicide whose primary active ingredient is Glyphosate, a non-selective, broad spectrum herbicide. The three most common GE crops in terms of cultivated land are Bt corn, RR corn and RR Soybeans (Gurian-Sherman, 2009), followed by Bt cotton and canola.

The first application of GE crops for human consumption was the *FlavrSavr Tomato* which gained FDA approval in 1994 (Bennett et. al, 2013; Bawa & Anilakumar, 2013), though it was not successful as the costs of production limited its profitability. More recently, *Golden rice* was designed to contain increased beta carotene in order to address Vitamin A deficiency and resultant blindness in developing countries (Gerasimova, 2016; Waters & Pajerowska-Mukhtar, 2012). Its results were mixed and controversial with some claiming its success in resolving malnutrition (Waters & Pajerowska-Mukhtar, 2012) and others arguing that it was a PR stunt aimed at giving a humanitarian stance to agrochemical corporations while not actually resolving the issue (Shiva, 2015; Gerasimova, 2016).

The five greatest adopters of GE crops are the U.S.A., Brazil, Argentina, India and Canada (ISAAA, 2014). Consequently, trends in agriculture in these countries over the last few decades have seen small, diversified, family run farms transition to large, industrialized, corporate owned, GE monocrops (Shiva, 2015; Bronson, 2015). Those in opposition to such transitions argue that farmer and consumer freedom of choice is restricted, food sovereignty and security are compromised, and that human and environmental health are put at risk. As it stands, the majority of EU countries have resisted the advances of GE agriculture, with Spain, Portugal, the Czech Republic and Slovakia being the only countries to have adopted the technology, and to comparatively small degrees (ISAAA, 2014). However, current political situations throughout Europe and the U.S.A. could see this change as right wing

parties gain popularity and corporations gain further power, for example with the current merger of Monsanto and Bayer ("Bayer agrees to", 2016). This could result in the potential for the industrialized model of GE monocrops to further dominate global agriculture and raise further issues with regard to the socioethical and environmental impacts that have already been noted throughout the literature.

In order to understand the significance for environmental management of a global agricultural landscape dominated by corporate-owned GE crops, it is necessary to understand the differences between industrial GE agriculture and traditional or organic agriculture. While systems exist which utilize a combination of characteristics, for the purpose of this thesis, traditional agriculture is defined as low input agriculture, often using organic principles, local, traditional knowledge, mixed farming systems, traditional plant breeding and seed saving. In contrast, industrial agriculture is defined as the system of agriculture that resulted from the Green Revolution, being resource intensive with regard to chemical fertilizers, pesticides and irrigation, consisting of large monocrops, and more recently, GE crops.

2.2.2. The Risk

The inherent risk involved in GE technology itself must be understood in order to assess the environmental ethics that may or not be breached as a result of its application in crop agriculture. "Risk is the probability of damage as the result of a hazard" (Heink, Bartz & Kowarik, 2012, p.4). Consequently, the risk being assessed is the likelihood of GE, the hazard, causing damage or harm to humans, or in the case of this thesis, the environment.

The risks of GE technology are described in detail by Smith (2003) in his book *Seeds of Deception*. The key argument of Smith's (2003) research is the unpredictable nature of the outcomes of GE, given the interaction of foreign genes with the host cell's natural regulatory processes. The processes of DNA coding, transcription, protein synthesis and gene expression involve many complex molecular interactions unique to the host organism, which can be disrupted and inappropriately initiated when foreign genes are introduced. For example, each gene is not responsible for a single protein or trait. Instead, many genes nearly always code for multiple proteins. As such, the insertion of foreign genes through the GE process is unlikely to result in the production of just one desired protein, and more likely to result in the production of many others with unpredictable side effects for the health of humans and the environment (Smith, 2003).

Furthermore, aside from natural cell regulatory processes, there are additional variables at play as a result of the GE process itself. After the foreign genes have been introduced to a group of host cells via *Agrobacterium* or Biolistic Gene delivery, the process of determining which cells successfully received the engineered gene depends on the use of antibiotic resistance markers (ARM) (Smith, 2003). Once the host cells have been subjected to the new genes, they are treated with an antibiotic which will kill all but the successful receivers of the new gene and its partner ARM gene (Smith, 2003). However, there is concern that the process of horizontal gene transfer may result in the transfer of such ARM genes to the humans and animals which ingest GE food, resulting in further antibiotic resistance (Smith, 2003).

Smith is not alone in expressing his concerns over the inherent risks involved in gene manipulation. Many others, despite expressing varying support of the technology itself, note the unpredictability of GE technology and the consequent implications for risk management (eg Marchant & Marchant, 1999; Bawa & Anilakumar, 2013; Boulter & Dale, 1997; Waters & Pajerowska-Mukhtar, 2012; Verhoog, 2007; Shrader-Frechette, 2005; and Gurian-Sherman, 2009). For example, pleiotropic effects (the effect of the introduced gene sequence on the host genome having the ability to promote or inhibit genes that would not normally be promoted or inhibited) are commonly noted as having the potential to heighten expressions of toxins and allergens as well as likely having further unpredictable effects (eg. Marchant & Marchant, 1999). Most agree that the risks associated with gene manipulation cannot be compared to the risks of traditional plant breeding (the risks of GE being much greater) (eg. Verhoog, 2007; Gurian-Sherman, 2009). Gurian-Sherman (2009), a member of the Union for Concerned Scientists, argues that gene interactions likely affect the crop in more ways than just yield capacity, and current regulatory procedures need to be tightened in order to recognize such risks before commercialization.

As a result of the necessity of such risk management practices, the precautionary principle is a key concept with regard to GE crops and their application. The precautionary principle demands that “where there is reason to regard a substance or a process as environmentally damaging, preventative action or regulation should be undertaken despite the absence of scientific certainty” (Attfield, 2014, p.156). The precautionary principle has been a part of Swedish and German environmental management policy since the 1960s and has since been adopted by many national governments and some international treaties (Myrh, 2010b). While it is a key component of the biocentric approach to environmental management, it is not exclusively a biocentic concept and should be employed by all, particularly those involved in biotechnology (Attfield, 2012). However, as will be demonstrated later,

application of the precautionary principle in practice is highly influenced by the worldview held and the consequent values employed.

2.2.3 The Controversy

Perhaps because of the risk involved in GE technology and its inherently unpredictable nature, the controversy surrounding the application of the technology in crop agriculture remains highly polarized (Bennett et al., 2013). Those in favour of GE centre their argument on the claim that risks of implementation are minimal, if not non-existent, and that humanity cannot survive without the benefits of GE technology (eg. Boulter & Dale, 1997). They argue that the world will not be able to support the projected 2050 population of 9 billion without GE crops and that solutions to problems such as climate change can only be solved by science and agricultural innovation. Proponents of crop GE claim that products undergo rigorous safety testing and risk assessment. The most common arguments used in favour of GE include:

1) the increased yield of GE crops;
2) the consequent economic and food security benefits of increased yield;
3) the decreased use of harmful pesticides;
4) the associated health benefits of decreased pesticide application;
5) the improved nutritional quality of food (Wu & Butz, 2004; Bennett et al., 2013);
6) reduced soil erosion as a result of low or no-till practices, and;
7) decreased greenhouse gas (GHG) emissions (Bennett et al., 2013).

In contrast, opponents of GE view the risks of implementation to humans and the environment as far greater than any possible benefits that could be experienced. Consequently, as opponents of GE are highly sceptical of the benefits to be had, they see no risk to human survival in not implementing the technology. Critics of GE argue that the technology is not necessary and that human life, together with the environment and its ecosystems, can be supported through alternative means such as organic methods, permaculture and traditional farming techniques using heirloom or local seeds (eg. Shiva, 2015; Gurian-Sherman, 2012). Finally, they argue that the risk assessment processes carried out on GE crops are inadequate. The common arguments against GE include:

1) the unacceptable level of risk associated with the technology due to its unpredictable nature (Verhoog, 2007);
2) moral and ethical concerns relating to the manipulation of organisms (Verhoog, 2007);
3) the increased use of pesticides, associated water and air pollution (Gurian-Sherman, 2009) and consequences for non-target species and biodiversity;

4) the formation of resistant pests (including both insects and plants, often referred to as superweeds) (Benbrook, 2012);
5) the unsustainability of large monocrops (Shiva, 2015);
6) the increased water demands of GE crops (Shiva, 2015);
7) decreased yield (Shiva, 2015), and;
8) the contamination of wild plant populations and non-GE agricultural crops with transgenes, either through self-seeding, cross-pollination or horizontal gene flow (Bagavathiannan et al., 2011).

A further argument used by proponents of GE is that manipulating the genetic makeup of plants has been in practice since the beginning of agriculture more than 10,000 years ago due to traditional plant breeding (Boulter & Dale, 1997). Consequently, the claim is often made that the risks resulting from GE are no greater than those associated with traditional plant breeding. Crop GE is described by some as a practice complementary to these traditional practices, with the only significant difference being noted as the use of a wider gene pool, allowing humans extra agency in selecting specific traits (Boulter & Dale, 1997; Marchant & Marchant, 1999). However, opponents see this wider gene pool as a core issue, inviting additional risk as a result of selecting genes from different species and kingdoms which would not naturally be able to interbreed with plants (Verhoog, 2007). It cannot be denied that while nature does indeed allow for the random shuffling of genes and for this process to be capitalized upon through selective breeding (Hettinger, 1995), GE in its present form is crossing a species divide that would never occur under natural circumstances (Dobson, 1995).

Another common justification made for GE crops is that the negative effects of GE agriculture for the environment are no different, or at least no worse, than agriculture itself, and that it is agriculture that is causing the issues, not GE technology (Bennett et al., 2013). Proponents refer to the destruction of habitat in order to make way for agricultural land and the use of pesticides as generic agricultural practice while listing the benefits of GE as though they can counter such issues (Bennett et al., 2013). For example, according to Bennett et al. (2013, p.263) GE has increased crop yields by 34%, enabling an increased crop yield to be achieved from a smaller land area and consequently reducing agriculture's GHG emissions. They also claim that reduced GHG emissions have been associated with low and no-till farming practices made possible by herbicide resistant crops and their associated herbicide regime (2013). Such claims are rebuffed by those who note the increased use of herbicides as a result of the herbicide resistant weeds that result from such a herbicide regime (eg. Benbrook, 2012), together with those who contend that yield

increases have not been significant, and when present, can be attributed to factors other than GE technology such as increased irrigation (eg. Gurian-Sherman, 2009; Shiva, 2015).

Through identifying the key arguments used by proponents and opponents of GE, it becomes clear that the two sides are arguing from different perspectives as a result of the different value systems at play. A common occurrence throughout the literature is for the same point to be made by the opposing sides to argue their case. For example, Waters and Pajerowska-Mukhtar (2012) while arguing in favour of GE, consider the speed with which new GE crop varieties can be created (in contrast to traditional breeding) as a significant advantage to the technology, while opponents see such speed as resulting in insufficient time to effectively determine the risk and possible side effects of the new variety. Waters and Pajerowska-Mukhtar (2012) also believe that the altering of a phenotype through the insertion of a gene from a different species is superior to traditional selective breeding practices for the wider gene pool available. For those concerned with the biological ethics of GE, it is the very same widened gene pool and lack of species distinction that makes GE unacceptable when compared to traditional plant breeding (Dobson, 1995). Similarly, proponents of GE argue that it reduces the use of harmful pesticides, supports biodiversity through the creation of new crop varieties and increases environmental sustainability. On the other hand, opponents argue that it increases the use of pesticides, decreases biodiversity through the use of large monocrops and the escape of transgenes and compromises environmental sustainability (eg. Bennett et. al., 2013). These examples directly counter each other, making it clear that the two sides are practicing different applications of the precautionary principle and risk assessment processes.

However, perhaps the most unsettling aspect of the controversy are the implications of corruption and cover-ups. Numerous examples exist from as early as the 1990s Pusztai affair to as recent as 2015. While the discrediting of Ahmad Pusztai's research on the effects of consuming GE potatoes in 1998 was the most high profile, it is clear that such practices continue. Séralini et. al.'s (2012, as cited in Mampuys & Brom, 2015) study on the effects of ingesting glyphosate and GE corn was similarly discredited. Even more recently, USDA researcher Jonathan Lundgren was silenced in late 2015 after his research on the effects of insecticides on non-target species showed negative impacts, specifically that neonicotinoids harmed butterflies (Roseboro, 2016). He has since founded Blue Dasher Farm to be a model of regenerative farming, a system which incorporates many organic principles and that Lundgren believes is the forefront of food production, being more resilient to pests and climate change than industrial, GE systems (Roseboro, 2016). However, such lack of

transparency raises serious implications for the impacts of corporatization on risk assessment and appropriate application of GE agriculture.

2.3. The Corporatization of Agriculture and Corporate Social Responsibility

2.3.1 The Corporatization of Agriculture

"Corporatization most often refers to a process in which services once provided by governments come to be owned and controlled by large, for-profit companies" (Busa & King, 2015, p.251). The corporatization of agriculture has been acknowledged and accepted in the literature (eg. Leguizamón, 2016; Bronson, 2015; Busa & King, 2015) and has significant implications for environmental ethics, and consequently environmental management. For example, there are many who argue that GE technology has the potential to provide solutions for environmental and social issues, but that the technology should not be under the control of corporations (e.g Lemmens, 2014; Hettinger, 1995). This raises questions as to how corporate application of GE technology might be inappropriate, and consequently, what other impacts corporatization might have on agricultural practices.

Agriculture was corporatized before the advent of GE as a result of the chemical inputs and hybrid seed varieties that emerged during the Green Revolution (eg. Bronson, 2015). The Green Revolution of the 20th century brought the industrialization of agriculture to developing or food insecure countries through the introduction of irrigation technologies, pesticides, fertilisers and high yielding crop varieties (Wu & Butz, 2004). It was claimed to successfully revolutionize agriculture in much of the world through enabling yield increases (Wu & Butz, 2004) in a similar way to which proponents expect GE to revolutionize agriculture. However, it is no coincidence that the arrival of the Green Revolution was synonymous with the end of WWII. The corporations who had been responsible for the production of war chemicals, redirected their applications to agriculture, as Shiva (2010), anti-GE activist explains: "every input in agriculture is a war chemical... herbicides were used in agent orange… fertilizers came out of explosive factories". However traditional seeds couldn't withstand such chemical inputs, resulting in the dwarf and hybrid varieties of the Green Revolution, also known as "high yielding varieties" or "miracle seeds" (Shiva, 2010). Shiva (2010) explains that the increased yield that was experienced in the Punjab region of India during the Green Revolution, was not a result of such miracle seeds and their associated inputs, but a result of the additional land and water that was diverted to the production of these crops. Furthermore, she maintains that had the same inputs of land and

water had been applied to traditional Indian agriculture, greater yield increases would have resulted. Consequently, the origins of corporate involvement in agriculture are not without controversy.

The hybrid varieties developed during the Green Revolution set a precedent with regard to the path that the corporatization of agriculture was to follow. As hybrid seeds produce a healthy crop but significantly limited progeny (Charnley, 2013; Van Wijk, 2004), the traditional practice of seed saving was rendered obsolete. This initiated the gradual rise of farmer dependence on agrochemical corporations as they became reliant on purchasing not only the chemical inputs, but also new seeds each season. Genetic Use Restriction Technologies (GURTs), or terminator technology, followed and eliminated the seed saving process through blocking the reproductive capacity of the plant at the genetic level (Bustos, 2008). Finally, the saving of corporate seeds became illegal with the advent of seed patents tying farmers to the purchase of corporate seeds each season (Waters & Pajerowska-Mukhtar, 2012).

Consequently, a significant component of the corporatization process stemmed from the ability to patent the GE technology contained within seeds. Prior to the Supreme Court's Diamond v. Chakrabarty case of 1980, living organisms were not strictly patentable, though a small number of single celled organisms had successfully received patents (Robinson & Medlock, 2005). However, the bacterium that microbiologist, Ananda Chakrabarty had engineered to break down crude oil (Robinson & Medlock, 2005) was deemed to be a "non-naturally occurring manufacture or composition of matter", a microorganism not considered legally alive for patenting purposes, and hence was patentable under section 101 of the U.S. Patent Act (U.S. Supreme Court, 1980). The U.S. Patent and Trademark office (PTO) initially declined Chakrabarty's 1972 patent request, however, the Supreme Court ruled narrowly (5 to 4) that "anything under the sun that is made by man" and hence does not occur naturally, can be patented, overruling the PTO and "opening the floodgates" for biopatents (Robinson & Medlock, 2005, p.12). RR soybeans were commercialized in 1996, followed later by RR corn and canola (Haugo, 2015). These crops now dominate the crop agriculture of many countries. Thus, the Diamond v. Chakrabarty case was a turning point in the history of GE, allowing for the complete commercialization of the technology, and ultimately corporatization of GE related agriculture.

Literature addressing GE agriculture often refers to issues surrounding such patenting and intellectual property rights (IPRs), specifically, their implications for seed saving. Many argue that restrictions to seed saving are immoral due to the consequences for food security and

the increased costs of buying new seed each season (Bustos, 2008; Shiva, 2015; Chen, 2014). Such costs force many small farmers out of business, further limiting crop production to large commercial operations (Dawson, 2012). Waters and Pajerowska-Mukhtar (2012, p.112) claim that "Monsanto has designed a system that literally traps farmers to continue using their product, as it is illegal to save patented seeds". Predictably, despite industry claims that eliminating seed saving is beneficial to farmers for the reduced labour that results, two independent studies found that such restrictions directly benefit corporate, industrial farms (Van Wijk, 2004), disadvantaging poor farmers on marginal land. According to Shiva (2015) corporate ownership of crop seed in India has resulted in the suicide of hundreds of farmers, driven to desperation by the debt accrued through the unpredictable yields GE crops and the entrapment cycle of having to buy new seed each season.

A common justification for biopatents is that IPRs are a necessary incentive to promote further technological innovation (Hettinger, 1995; Barbieri & Bocchi, 2015). However, Hettinger (1995), despite being in favour of biotechnology, argues strongly against such biopatents and states that these proposed benefits are unproven and that the contrary is true: Biopatents are more likely to restrict innovation through inhibiting the sharing of information and ideas, while publicly funded research arguably allows society a greater access to the technology and how it used. This is clear when comparing current rates in innovation with that of traditional plant breeding in the 19th century which had no IPRs to encourage innovation, and yet underwent huge leaps of progress (Charnley, 2013). Consequently, biopatents appear to serve only the corporations to whom they belong with no benefits for individual farmers, farming practice, or the environment.

One direct consequence of biopatents has been the growth of monopolies over the agrochemical industry. Currently, commercial GE crops are almost completely controlled by the private sector, of which Monsanto is the dominant corporation (Bennett et al., 2013). Monsanto is a multi-billion dollar corporation (Glover, 2007) and one of the most well-known agrochemical companies in the world due to the high profile that Monsanto controversies have been given by the media and anti-GE campaigns. It claims to be a sustainable agriculture company, marketing itself as a company tackling climate change, providing food for developing countries and supporting honey bee populations (Monsanto, 2017a). However, it has also been the subject of much ridicule and controversy (Charlebois & Van Acker, 2015). For example, the *March Against Monsanto* demonstrations that were held in over 50 countries aptly show the widespread dissent (Biddle, 2017). Meanwhile, recent court cases in the U.S.A. such as Bowman v. Monsanto and Monsanto v. Schmeiser, have effectively pitted farmers against the corporation, over issues such as seed saving and the

ownership of seeds, that until 1980s were unquestioned traditional farming practices (Haugo, 2015). Between 1997 and 2015, Monsanto claims to have sued 145 farmers and won all of the 11 cases that went to court (Haugo, 2015).

The monopoly that Monsanto holds over the agricultural industry raises significant ethical issues. Proponents of GE often state the high incidence of adoption as proof of the technology's popularity. However, such adoption rates are likely to be a result of corporate influence on the agricultural market as opposed to genuine popularity (Bustos, 2008). Aggressive marketing techniques used by Monsanto could contribute to the adoption of seeds that otherwise would not be purchased if farmers understood the true consequences of using such seeds, or had the information required to make informed decisions surrounding the actual benefits to be gained (Bustos, 2008). This perspective is strong amongst anti-GE activists who argue that the monopoly held by agrochemical corporations has drastically reduced the variety of non-GE seeds available on the market, pressuring farmers into purchasing patented GE seed (Roseboro, 2013). Through a series of strategic mergers, Monsanto now controls the sale of more than 90% of GE seed (Dawson, 2012) and through the patenting of transgenic technology, can claim ownership of agricultural processes from start to finish (Moss, 2011). "By 1999, Monsanto alone had accumulated approximately 650 plant-related patents that would become necessary for future seed research and, by 2004, Monsanto had an almost 30% share of all research and development in the biotechnology industry." (Bronson, 2015, p.72).

Furthermore, activists such as Shiva (2015) argue that while Monsanto claims to be combatting environmental issues and supporting food security with its GE applications, the vast majority of its funding and research is used to produce "cash crops", such as RR varieties. These crops essentially form a "package deal" (Shiva, 2015), as farmers must purchase Monsanto's herbicide, Roundup©, in order for the purported benefits to be had, together with purchasing new seed each season (Waters & Pajerowska-Mukhtar, 2012). Monsanto claims that the profits to be had from increased yield more than compensate for the increased input costs, a claim that remains controversial. Meanwhile, though GE has been an industry of substantial financial and technological resource since the 1970s, no crops have yet been produced which effectively combat any food security or climate change related issues (Gurian-Sherman, 2012). Instead, as noted earlier, the vast majority of GE crops in circulation are herbicide resistant varieties. Consequently, it is clear the corporate application of GE technology in crop agriculture is focussed on profit and marketability over genuine environmental concern.

Nitrogen (N) pollution serves as a good example in demonstrating the effects of corporatization on agricultural practices and consequently, environmental management. N fertilizer is a significant source of nitrous oxide, a potent GHG, of which agriculture is responsible for 68% in the U.S.A. (Stuart & Schewe, 2016). One proposed strategy to mitigate excess N is the improvement of N uptake efficiency (NUE) of crops through GE technology (Gurian-Sherman & Gurwick, 2009). However, as with the insertion of other foreign genes, NUE genes were found to interact in unexpected ways with the host genome, resulting in decreased resistance to pathogens and changed toxicological properties (Gurian-Sherman & Gurwick, 2009). In contrast, traditional plant breeding is a safer and more efficient way to incorporate NUE genes into crops, as there are a large variety of NUE genes already present in current crops that do not need to be introduced from different species (Gurian-Sherman & Gurwick, 2009). Furthermore, other methods for reducing nitrogen pollution such as precision farming and cover crops could be equally, if not more effective, resulting in GE solutions being an unnecessary gamble (Gurian-Sherman & Gurwick, 2009; Gurian-Sherman, 2012). Finally, according to Stuart and Schewe (2016, p.371), approximately 50% of farms apply more fertilizer than they need to. Therefore, reducing the application of nitrogen fertilizer is one of the most effective steps that a farmer could take to mitigate climate change, and yet shockingly, agrochemical corporations "continue to create incentives for over-applying nitrogen fertilizer" (Stuart & Schewe, 2016, p.371). This clearly demonstrates the corporate agenda in giving GE technology an unreasonable priority purely as a means for profit, when perfectly effective, non-GE alternatives exist. In light of this agenda, it necessary to ask what responsibilities corporations should accept with regard to impacts on the environment.

2.3.2. Corporate Social Responsibility

Corporate environmental responsibility (CER) is contained within the paradigm of corporate social responsibility (CSR) (Okada & Watanabe, 2008; Karassin & Bar-Haim, 2016) and includes the responsibility to reduce the use of chemicals, and support the conservation of ecosystems (Okada & Watanabe, 2008). A company is obliged to consider the "social, ethical and environmental… interests of its stakeholders", and consequently, its concerns must go further than merely shareholder value (Hummels & Timmer, 2004, p.73). Furthermore, "firms should ensure that the environmental costs associated with their activities are incorporated into the cost of their products, rather than be externalized and borne by society" (Clapp, 2007, p.348). However, it has long been recognized that such responsibilities are often neglected and that mainstream corporations have been the root cause of the vast majority of environmental issues and climate change drivers (Brenkert, 1995; Walker & Wan, 2012). One potential reason for this is that corporations consider

themselves liable to business ethics but not environmental ethics (Brenkert, 1995). As a result, corporations will always prioritize profit and shareholder satisfaction over ethics and stakeholder satisfaction. Meanwhile, the economic business model that corporations adhere to is dependent on growth, with no capacity for a sustainable economy to take priority (Brenkert, 1995). Finally, the fact that CSR remains a voluntary practice has allowed corporations to adopt their own understanding of the practices, redefining sustainable development with terms such as "sustainable growth" and "sustainable competitiveness", both arguably unsustainable concepts (Glover, 2007, p.12).

Despite CSR being a voluntary initiative, even when regulations do exist, "[a] number of factors, associated with the structural power of corporations, can effectively shelter multinational companies from demands for accountability and allow them to respond (or decline to respond) at their discretion" (Glover, 2007, p.11). This is in part due to the conflicting characteristics of corporations that attribute them certain rights while absolving them of certain responsibilities. Corporations are attributed the legal rights of a person (Foster, 2010; Achbar, Abbott & Bakan, 2004), thus making it imperative that this 'person' is held morally accountable for his actions. However, in part due to the transnational nature of most corporations, this is the source of considerable struggle, and a struggle which resulted in the makers of documentary *The Corporation* (Achbar et al., 2004) diagnosing the average corporation as a psychopath. Consequently, whether such morally immune entities can apply appropriate moral considerations to GE technology is debateable.

GE raises a unique set of ethical considerations and has consequently attracted significant attention with regard to CSR in the literature. Some argue the need for a model of CSR developed specifically for the agrochemical industry due to the unique ethical implications of GE (eg. Okada & Watanabe, 2008). They describe the need for "genome-conscious management" due to the potential for significant and far reaching impacts on humans, animals and the environment. Their premise is that "GE companies must not undervalue either the instrumental or the intrinsic values of the environment, plants, and animals" (Okada & Watanabe, 2008, p.160). However, all of the aforementioned responsibilities ultimately represent ideals. The likelihood of such ideals being incorporated in corporate practice appears slim, particularly with regard to GE.

However, despite the slim likelihood of CSR ideals being incorporated in corporate environmental practice, corporations have taken on board the benefits to be had from appearing environmentally conscious. As a result, corporate applications of CSR have been labelled "green washing" by those sceptical of their motivations (symbolic actions with little

practical benefit) (eg. Walker & Wan, 2012). The methods of CSR employed by corporations such as Monsanto are undoubtedly strategic moves in order to secure competitive market positions and favourable public relations. Glover (2007, p.11) explains that the "business case" for sustainable development is centred on securing a "social licence to operate" and ultimately prioritises profit, ensuring that social responsibilities will only be acted on if they allow for profit, or at the very least for business to continue unaffected. Consequently, "the cultural construction of corporations as morally legitimate enterprises" has played a significant role in the evolution of corporations (Foster, 2010, p.98) as they responded to the need to anthropomorphise, as it were, the corporate entity, in order to restore public faith.

Monsanto's *Smallholder Program* (SHP)[1] is an example of such a strategic move as Glover's (2007) study shows that while Monsanto's motivations for implementing the SHP weren't entirely altruistic, and that the merging of business aims and CSR is a difficult balance to strike in practice. Similarly, *The New Monsanto Pledge*[2] announced by CEO Hendrik Verfaillie in 2000, "effectively portrayed Monsanto as a provider of technology to resource-poor farmers and an important contributor to sustainable agriculture and food security" (Glover, 2007, p.20). It specifically stated a "commitment not to pursue technologies that result in sterile seeds" (Glover, 2007, p.22), a commitment which is irrelevant in light of seed patenting which achieves the same ends and was not included in the pledge. Consequently, CSR in the agrochemical industry faces many challenges both in practice and with regard to employing appropriate ethics.

2.4. Pesticides, Yield and Biodiversity

2.4.1. Pesticides

While the technology of GE itself carries inherent risks, its link to pesticide use is significant within the controversy. Pesticides are synthetic chemicals manufactured for the purpose of killing plant (herbicides) and animal (insecticide) species that are considered pests in the agricultural world. There are many human and environmental health concerns relating to the use of pesticides and these concerns are used both in favour of GE and against it. The common arguments in favour of GE relate to its proposed ability to reduce the use of 'harmful' pesticides, consequently benefiting the health of the environment, farmers and consumers (Bennett et al., 2013; Herdt 2006; Qaim, 2010). This has proved true to a degree for Bt crops which have decreased the need for external insecticide application, however, the use of herbicides, specifically Roundup© has increased significantly as a result of

[1] The SHP aimed to provide support for 'resource poor' farmers in India, essentially promoting Monsanto's GE products in regions where the industry had not yet been established (Glover, 2007).
[2] The Pledge was a corporate code of conduct instigated in part to restore the public's faith in GE technology and Monsanto Company after consumer rejection of GMO in the 1990s (Glover, 2007).

herbicide resistant crops (Benbrook, 2012, p.2; Bennett et al., 2013). Benbrook (2012), carried out an extensive study on the trajectory of pesticide use in the U.S. in response to GE crops for the Union of Concerned Scientists (UCS). He expects Bt crops to follow the same trajectory as RR, as insects become resistant to the Bt Cry toxin and additional pesticides are required.

According to Marchant and Marchant (1999), who conducted a review of the issues associated with GE crops, the advantages of herbicide resistant crops include: 1) improved weed control efficiency; 2) improved yield and crop quality; 3) reduced herbicide applications; 4) increased use of environmentally friendly herbicides; and 5) reduced crop tillage and consequently decreased soil erosion and water loss. Meanwhile, they contend that the disadvantages of herbicide resistant crops include: 1) the increased need for extensive herbicide weed control; 2) a likely increase in herbicide use; 3) the creation of superweeds (herbicide resistant weeds); 4) the possible creation of a herbicide 'arms race' amongst agrochemical corporations; 5) the encouragement of greater use of environmentally deleterious herbicides; 6) the tying of the farmer to a single chemical supplier with less autonomous farmer control of the crop, and; 7) reduced plant and animal biodiversity. However, many of these claims were simply listed and not backed up by evidence or cancel each other out, clearly representing the muddle within which much of the debate surrounding pesticides and GE resides.

An example of a problematic claim made about pesticides can be found in the "environmentally friendly" herbicide referred to by Marchant and Marchant (1999). Marchant and Marchant (1999) claim that glyphosate is less toxic to invertebrates and more easily broken down by soil microbes than other pesticides. However, there are many of the opinion that Roundup© is toxic enough to cause serious concern. According to Shrader-Frechette (2005), Roundup© is toxic to plants and animals at doses as low as 10ppm, as well as bioaccumulating up the food chain. While Benbrook's claim for glyphosate's favourable toxicology properties was quoted by Bennett et al. (2013, p.264), read in context, his claim was referring to glyphosate's less persistent nature when compared to those that it displaced, such as DDT. In reality, Benbrook's study found that the development of glyphosate resistant crops such as RR soybeans and canola, resulted in an increase in overall pesticide use of about 7% between the years of 1996 and 2011 (2012, p. 3). He acknowledges that while glyphosate is "among the safer herbicides per hectare" (p.5), it's rate of use and consequent human exposure is rising significantly which undoubtedly increases the risks. In particular the risk of exposure as a result of natural air and water movement and contamination of neighbouring crops is high (Benbrook, 2012). Furthermore,

Mesnage, Defarge, Spiroux de Vendômois and Séralini's (2014) study on the effects of glyphosate together with Roundup©'s remaining ingredients highlighted the issue that it may not be glyphosate in isolation, but glyphosate in combination with adjuvants present in the Roundup© formulation that pose serious health risks. This is a factor that is notably absent from studies on the safety of glyphosate carried out by Monsanto scientists (eg. Von Mérey, Manson, Mehrsheikh Sutton & Levine, 2016).

Pest resistance has proven to be a significant issue in relation to the pesticide use associated with GE crops. Insects targeted by pesticides regularly respond with a heightened resurgence after spraying and then proceed to adapt and generate immunity through Darwin's survival of the fittest principle (Carson, 1962). Increasingly rigorous doses and varieties of pesticide are applied in attempts to stay one step ahead. This "chemical war" that Carson (1962) referred to decades ago is now disturbingly relevant for glyphosate, no longer adequate for weed control (Benbrook, 2012; Chen, 2014), and Monsanto's endless race to include new chemicals with increased toxicity within its pesticide formulations. As herbicide resistant GE crops became commercialized in the mid-1990s, Monsanto's scientists reported that the chances of herbicide resistant weeds were unlikely, an assertion that was rebuked by other scientists who called for additional non-chemical methods of weed control in order to prevent such resistance (Benbrook, 2012). Glyphosate resistant weeds are now a serious problem with an estimated 50-60 million acres impacted as at 2012, a figure that is set to grow. This significantly increases the cost of pest management for farmers, on top of the already higher seed price for GE seeds when compared to non-GE[3] (Benbrook, 2012, p.4). Consequently, pesticides form a significant component of the debate surrounding GE crops and corporatization.

2.4.2 Yield

The claim that GE crops have yield advantages over conventional crops is used as the foundation for many of the arguments in favour of GE. Increased yield implies increased efficiency which results in increased profits. Increased efficiency lends itself to claims for reduced inputs and resultant decreased environmental pressure and contributions to climate change. Finally and most commonly, increased yield is the primary solution cited for solving food security issues in light of a growing population and the challenges that developing countries currently face (Lammerts van Bueren & Struik, 2005).

[3] Conventional soybean seeds retail for $28/bag while RR seeds retail for $36 - $59/bag plus the cost of Roundup© (EMS, 2017).

However, the concept of yield improvement as a result of GE is a misnomer that, having been manipulated by agrochemical corporations, deserves explanation. No single gene, GE or otherwise, results in an increase of yield, as Gurian-Sherman (2009) explains: Yield is a product of a large number of genes in combination with each other and particular environmental conditions. The traits that are altered by GE are the traits that confer resistance to environmental pressures such as pests, thus increasing the operational yield as opposed to intrinsic yield. Operational yield is the yield that is achieved when realistic, less than ideal environmental conditions are at play, such as pest presence, while intrinsic yield, or potential yield, is defined as the maximum yield that could be gained under optimum environmental conditions (Gurian-Sherman, 2009). For example, the increase in the operational yield of Bt corn has been found to be 7-12% when pest incidences are high, but no yield advantage is found when pest incidences are low (Gurian-Sherman, 2009). Bt and RR crops have been marketed by Monsanto specifically for their increased yields. According to Bury's (2013) statistics, Bt cotton is 19% responsible for increased cotton yields in India. However, Shiva (2015) contests that this figure is more to do with the increased irrigation than the Bt technology itself. Bury (2013) concedes that Bt cotton should not be celebrated as a "miracle solution", due to the heavy water requirements of cotton farming, and the variable yields experienced, of which farmers are often not forewarned.

Pest resistant varieties aside, the argument for the increased yield of RR crops is a fragile one. After Monsanto's first generation of RR Soybeans patent expired in 2014, it was acknowledged that the expected yield advantages had not come to light, and a second generation was introduced with a promised yield increase of 7-11% (Haugo, 2015, p.741). However, how this increased yield is to be achieved, is not clear, as the only genetic difference from conventional soybeans is the glyphosate resistance (Haugo, 2015). The timely introduction of the second generation variety was aimed to encourage farmers to continue to buy the patented seeds as opposed to saving the now unpatented first generation variety (Haugo, 2015). Gurian-Sherman (2009) found that RR corn and soybeans have not succeeded in increasing operational yield, implying that farmers' adoption of the seeds is more likely related to factors other than yield advantages. Significantly, Gurian-Sherman (2009) also found that no GE crops have so far succeeded in increasing intrinsic yield, while traditional breeding has. Gurian-Sherman is also doubtful of the potential for GE to significantly impact yield in the future, as the success rates of proposed varieties thus far have been low, with only Bt corn succeeding in increasing yield out of the thousands of field trials completed, and the actual increase being significantly less than the increases experienced from traditional breeding.

Bennett et al. (2013) agree that the actual effects on yield are much more complicated, and depending on certain variables, GE technology may reduce yield in some instances. Bennett et al. (2013, p.257) describe, for example, the likelihood of 'yield drag' ("a negative effect on yield that may result from inserting a specific trait that, for example, may require extra energy or may otherwise negatively affect the yield") occurring if the technology is applied to generic commercial varieties rather than locally adapted varieties, or in seasons with low pest incidence. Similarly, Shiva (2015) argues that GE crops require greater inputs of synthetic pesticides, herbicides and fertilizers as well as a greater volume of water, all for a comparatively lower yield of produce, making traditional non-GE varieties more sustainable. She also argues that just as GDP is an inaccurate measure of wellbeing for a country, crop yield is ineffective in reflecting the true inputs and outputs of an agricultural system with the many associated environmental and health effects.

2.4.3. Biodiversity

The primary argument used in opposition to GE crops and the effects of corporatization on agriculture involves biodiversity and the implications for integrity, ecosystem health and the environmental sustainability of agriculture. The 1992 Convention on Biological Diversity, constructed in aid of sustainable development (Herdt, 2006), defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (Heink et al., 2012, p.5). Proponents of GE crops argue either that it is agriculture itself that impacts biodiversity rather than GE specifically (Bennett et. al., 2013), or that the technology supports biodiversity through the creation of additional varieties (Gregorowius, Lindemann-Matthies & Huppenbauer, 2011). Those against GE and corporatization argue that the industrial model of corporate, GE farms results in large monocrops which require large doses of pesticides to remain viable (Timmermann & Robaey, 2016). This in conjunction with the escape of transgenes from such monocrops via horizontal gene flow has implications for biodiversity both on and off farm (Clapp, 2007; Bennett et. al., 2013; Timmermann & Robaey, 2016). Increased applications of herbicides on herbicide resistant GE crops have reduced the biodiversity of non-target plant and animal species (Timmermann & Robaey, 2016). Honey bees have been seriously implicated by pesticide use (Liu, Pan & Li, 2014) with significant consequences for pollination and hence biodiversity. Genetic erosion - the loss of genetic variation within species - has also become a major problem making large monocultures much more vulnerable to climatic variations and disease (Timmermann & Robaey, 2016; Peres, 2015).

Regardless of how or whether GE impacts biodiversity, there is a consensus in the literature that biodiversity, both wild and agricultural has decreased (Bennett et. al., 2013; Timmermann & Robaey, 2016). Timmermann and Robaey (2016) describe the current state of agrobiodiversity as impoverished, with only 1.4% of available crop species relied upon for over 90% of global food production. Meanwhile according to Ma (2012, p.712), while the human diet historically consisted of over 100 plant species, 12 species now provide for 80% of our food, the majority of which is GE. Shiva (2015) paints an even more dramatic picture claiming that the human diet has been reduced from a variety of thousands of plant species to as few as eight. Statistics from the Food and Agriculture Organization of the United Nations (FOA) (n.d.) state that three crops (rice, maize and wheat) provide 60% of global food requirements.

It should be noted that threats to biodiversity are not recent or specifically a result of GE crops. Just as hybrids were the precursor to the patenting of GE crops and consequent corporatization, the Green Revolution was the precursor to GE agriculture's reliance on pesticides. Many argue that the global dominance of the Green Revolution and its purported high yield crops resulted, and still is resulting in significant loss of genetic biodiversity (Peres, 2015). Rachel Carson's *Silent Spring* (1962) focussed the world's attention on the environmental impacts of the very synthetic chemicals that the Green Revolution celebrated, highlighting their vastly inappropriate use and devastating consequences. Her argument is now as relevant as ever as the corporate control of agriculture maintains this reliance on synthetic chemical inputs with ongoing implications for biodiversity.

2.5. Environmental Ethics

An environmental ethic should provide answers to two fundamental questions: "what nature should we care about, and why?" (Scoville, 2016, p.79). The answers to these questions vary significantly depending on the worldview held and the consequent value attributed to different aspects of the environment. If something is deemed to have intrinsic value, it has a good of its own, and consequently, moral standing (Attfield, 2014). Once an entity is deemed to have moral standing, it is agreed that measures should be taken to avoid doing harm (Attfield, 2014). Anthropocentrism, biocentrism and ecocentrism are worldviews, or value-theories, within environmental ethics which lie on a spectrum defined by the different values that they prioritize, significantly the degree of intrinsic value attributed to humans and different components of the environment. Pure anthropocentrism lies at one end, attributing only humans intrinsic value, while pure ecocentrism lies at the other, attributing intrinsic value to all living organisms and the systems which support them. Different forms of

biocentrism lie along the spectrum between anthropocentrism and ecocentrism, depending on whether living organisms are attributed a hierarchy or equal moral standing, and whether wholes such as species are included. Consequently, while biocentrism can be considered to be a less extreme forms of ecocentrism (Attfield, 2014), biocentrism and ecocentrism represent a compatible approach to environmental ethics for the purpose of this thesis, while anthropocentrism provides a contrast.

Anthropocentrism fosters a duality in the perception of human and environmental interests, viewing them as distinct and separate (Purser et al.,1995) and is inherently reductionist. Anthropocentrists are more likely to seek mastery over, and possession of the natural world (Dobson, 1995). In contrast, biocentrists and ecocentrists seek equality with, and stewardship of the environment and are more holistic, recognizing the interconnectedness of humans activity and environmental consequences (Gladwin et al., 1995; Dobson, 1995). Ecocentrism believes in the environment's intrinsic value irrespective of its utility for humans and therefore places limits on the use of natural resources (Gladwin et al., 1995). The ecocentric perspective views the human population as already exceeding the carrying capacity of the earth, resulting in negative consequences for the environment (Gladwin et al., 1995). Finally, ecocentrism recognizes that "[v]irtually all production and welfare are totally dependent on ecological health, integrity, and abundance [and that] [t]echnological substitutes are not plausible for most critical nonrenewable natural resources and life-support functions" (Gladwin et al., 1995, p.887).

Lying on a slightly separate branch of the spectrum, technocentrism is a perspective dominated by the reliance on and belief in technology to solve environmental problems and cater for the ever expanding human population (Edward, 2015). The technocentric paradigm has its roots in the scientific revolution of the 1600s and is a reductionist school of thought that places humans above and separate from the environment (Gladwin et al., 1995), fostering a dualism and disconnectedness in a similar way to anthropocentrism. Technocentrists see population growth as a positive force for driving the economy and technological innovation (Gladwin et al., 1995). They "see the solution for woes brought on by human ingenuity as more ingenuity" (Edward, 2015). Consequently, while subtle differences exist between anthropocentrism and technocentrism, and biocentrism and ecocentrism respectively, the two pairs form relative opposites in many regards. Table 1 summarizes the broad characteristics of each worldview:

Table 1: Worldviews

	Anthropocentrism	Technocentrism	Biocentrism	Ecocentrism
Presence of Hierarchy	Attributes humans a hierarchy over nature and ascribes intrinsic value only to humans.	Attributes humans a hierarchy over nature and ascribes intrinsic value only to humans.	Attributes a degree of hierarchy but ascribes intrinsic value to all sentient beings.	Attributes no hierarchy and ascribes intrinsic value to all sentient beings as individuals and collective wholes.
Utilitarian vs. Intrinsic Value	Utilitarian value is ascribed to resources of benefit to humans.	Utilitarian value is ascribed to resources of benefit to humans.	Utilitarian value is ascribed to resources of benefit to any living being.	Intrinsic value can also be ascribed to resources.
Reductive vs. Holistic	Mostly reductive but can have some holistic elements.	Reductive.	Mostly holistic but can have some reductive elements.	Holistic.
Environmental Resource Management Approach	The environment and its resources are available for human exploitation with no consequences.	The environment and its resources are available for human exploitation with no consequences.	The environment and its resources should be treated with respect and managed sustainably as there are negative consequences to exploitation.	The environment and its resources should be treated with respect and managed sustainably as there are negative consequences to exploitation.
The Position of Humans	Humans are seen as separate and distinct from the environment.	Humans are seen as separate and distinct from the environment.	Humans are not separate but inherently part of the environment.	Humans are not separate but inherently part of the environment.

However, worldviews “rarely take the form of highly developed systematic philosophies, typically remaining sets of background assumptions that tend to organize language, thoughts, perceptions, and actions” (Gladwin et al., 1995, p.880). Consequently, people are often not aware of the worldview they hold or how it shapes their perception of certain issues (Gladwin et al., 1995). This is significant when attempting to understand the decision making processes of different groups of people when considering the appropriate application of GE technology. One study found that knowledge did not factor significantly in shaping the attitudes of scientists towards the patenting of living organisms, implying that the worldview held may have been a more significant factor in this case (Siegrist, 1998). The same study showed a direct correlation between worldview and acceptance of GE technology:

“Ecocentrism had a negative influence on attitudes towards gene technology, while anthropocentrism and apathy towards environmental issues had positive effects” (Siegrist, 1998, p.864). The stances held by pro and anti-GE camps have been noted by others as synonymous with anthropocentric and biocentric world views respectively (eg. Dobson, 1995). Some biocentric views hold that GE should be condemned for its attempt to dominate nature and that such domination is at least partly responsible for environmental degradation, while others focus on the interference of GE with the telos, or integrity of the individual organism or species (Dobson, 1995). Consequently, framing the environmental ethics issues of GE crops and corporatization around the worldviews typically expected to be held by those involved, contributes significantly to understanding the controversy.

2.6. Summary

This chapter has provided the background information on the issues associated with the corporate application of GE in crop agriculture. The basic science behind GE technology and the associated risks involved were explained, together with the core arguments used for and against GE crops. The corporatization of agriculture is described with regard to its historical underpinnings and the role that the Green Revolution and later GE technology had in allowing for such corporatization. CSR is then explained with regard to the degree of responsibility that corporations should be taking for environmental welfare. Finally, key concepts such as yield, pesticide use and biodiversity are explained given their significance in the controversy. This background information was used to identify the working concepts that were used to organise the literature analysis. The results of the literature analysis are presented in Chapter 4. The following chapter explains the methodology used for the research analysis.

Chapter 3 Methodology

3.1. Introduction

This chapter will describe the research methodology used for this thesis, the parameters involved, and the advantages and disadvantages of the selected research method. This thesis was composed of a literature based methodology consisting of a structured literature review using an interpretive approach, framed by an understanding of hermeneutics. After explaining the rationale for the chosen methodology, the literature search is described with regard to the key words used. The selection process of relevant articles and criteria for elimination are then described. Finally, the categorizing of the literature to be used for the analysis is explained followed by the research questions that were used to extract the relevant information from the selected articles. The Framework provided by the environmental ethics worldviews of anthropocentrism, technocentrism, biocentrism and ecocentrism is explained with regard to how it allowed for the analysis of the working concepts and consequently contributed to the research objectives. Considerations of ethics with regard to the methodology were not applicable due to the exclusive use of secondary data.

The aim of this thesis was to establish whether the corporatization of agriculture, and the consequent corporate application of crop GE, results in breaches of environmental ethics, as defined by the worldviews of biocentrism and ecocentrism, according to recent peer-reviewed literature. The research objectives that were used to achieve this aim are as follows:

1. Establish the level of risk associated with GE crops through identifying the concerns raised.

2.Establish the implications of crop GE on the environment and the consequent implications for environmental ethics as a result of such risks.

3. Establish the degree to which agriculture has been corporatized and the implications of such corporatization on the environment, significantly, through the corporate application of GE and compromises to the risk assessment process.

4. Establish the degree to which corporatization and the corporate application of GE can be explained by the world views of anthropocentrism and technocentrism, the benefits to be had from incorporating biocentric and ecocentric values, and the likelihood of such inclusion.

3.2. Justifications

Using a literature analysis as research methodology is a less common research strategy for masters' theses than the collection of primary data, but one that contains unique advantages and can result in a deeper insight into the subject matter (Armitage & Keeble-Allen, 2008). With regard to the environmental management issues surrounding the corporatization of agriculture and GE crops, the debate has become so polarized and controversial that to collect further primary data may not have contributed to the field as effectively as a review of the data that already exists. In particular, the synthesizing of bodies of literature into coherent arguments is important when the degree of bias is as high as with the corporatization and GE controversies. Media reporting that is based on singular studies can exacerbate bias that might already be present and have implications for management policy (Armitage & Keeble-Allen, 2008). Literature analyses allow for the influence of such bias to be mitigated, and for the lessons from existing research to be applied to management practice or policy.

The literature for this research analysis was restricted to peer reviewed journal articles from the last 10 year period for multiple reasons. Firstly, for practicality reasons: A good quality systematic literature review would investigate the methodological soundness of the literature selected for review, but in doing so would add a significant workload (Armitage & Keeble-Allen, 2008). Being a masters' thesis, such quality checks were unfeasible, resulting in the reliance on the peer review process. The other reasons for the restrictions relate to the research aim and objectives. As the subject area of this thesis is embroiled with such a degree of controversy and conspiracy, it was important to ascertain the degree to which the issue is being seriously considered by the scientific community, and how much of it is popular excitement, fear, or ignorance. Choosing only peer reviewed articles from the last 10 years allowed for a current picture to be painted on behalf of the debate that resides in the academic field, irrespective of media influence. Meanwhile, by choosing only peer reviewed journal articles, the credibility of the results were ensured. This is because if the results showed a breach in environmental ethics without having relied upon the arguments of activists in non-peer reviewed literature, such breaches could not be denied by the responsible parties. This is significant given that the peer review process may not be completely immune to corporate influence.

3.3. Methodology

There is a lack of of methodological frameworks available for literature reviews as a research method that are suitable for small-scale literature based research reports such as masters'

theses (Armitage & Keeble-Allen, 2008). Armitage & Keeble-Allen (2008) attempted to resolve this through the formation of the Rapid Structured Literature Review (RSLR) which takes key components of both traditional and systematic literature reviews and frames them through an interpretive approach within the paradigm of hermeneutics. Traditional literature reviews best describe the literature reviews commonly used within research publications in order to place the research in its relevant context. They leave room for flexibility in altering the research question as the research progresses. Systematic literature reviews were developed in order to structure the traditional literature review so that it could be used as a research method in its own right (Boell & Cecez-Kecmanovic, 2010). Systematic literature reviews state a clear hypothesis to be tested, attempt to locate all relevant literature, examine the methodologies of the literature to be included, state explicitly which is to be included and why, and form conclusions based on the literature with the most robust methodologies. However, while systematic literature reviews aim to be "unbiased, complete and reproducible", Boell and Cecez-Kecmanovic (2010, p.130) explain that this is often unachievable regardless of such structure, and instead propose the use of a hermeneutics framework. The compromise found in Armitage & Keeble-Allen's (2008) RSLR includes the flexibility in forming the hypothesis as the research progresses through the understanding of hermeneutics, while systematically considering a wide range of literature in order to present an unbiased overview of the subject matter.

Hermeneutics "describes the literature review process as being constituted by literature searching, classifying and mapping, critical assessment, and argument development" during which the literature is continually engaged with as the body of literature and understanding of the subject matter increases (Boell & Cecez-Kecmanovic, 2014, p. 257). "Using a hermeneutic approach, retrieving small sets of highly relevant publications is preferable to large sets of documents whose relevance cannot be sufficiently judged" (Boell & Cecez-Kecmanovic, 2014, p.278). Hermeneutics also adds a further dimension to the use of the conceptual framework of worldviews to explain the different attitudes towards GE. In its most fundamental form, hermeneutics is described as the theory of interpretation. Interpretation of what constitutes harm plays a key role in determining whether environmental ethics are breached. Thus, an understanding of hermeneutics can be applied in order to understand the different values that result from the different worldviews. Finally, the inclusion of the hermeneutics framework allowed for the evolution of the research aim as the research progressed. The research began with the broad aim of investigating the ethics involved in the corporate control of agriculture and crop genetic engineering. The complex nature of the link between corporatization and GE and their relevant roles in contributing to breaches in

environmental ethics became clear as the research progressed and resulted in a refined research aim and group of objectives.

O'Leary (2009) provides additional considerations with regard to a research method that relies exclusively on secondary data. As with primary data, a strategic analysis must be applied. In a literature based methodology this is achieved through "interviewing" the selected literature. O'Leary (2009, p.251) explains that by "'interviewing' your documents, you are, in a sense, treating each document as a respondent who can provide you with the information relevant to your inquiry". According to O'Leary (2009), the advantages to using pre-existing literature as the data source include allowing for a non-biased collection of data as there is no risk of imposing a bias on interview participants, while also capitalizing on the large amount of data that already exists and hence more clearly identifying the gaps or opportunities for further research. However, O'Leary (2009) also acknowledges the challenges presented by a reliance on second data. For example: 1) using data that was generated for a different purpose and hence will not always be directly relevant to the research question at hand; 2) having to ensure that the research objective doesn't create bias in interpretation of the data or take it out of context; and 3) having to take into account the agenda of the data and its credibility. These challenges were outweighed by the benefits throughout this thesis.

3.4. Method

The research method consisted of key word searches of the *Discover*[4] metasearch engine of databases at Massey University, 2017, for peer reviewed journal articles published within the last 10 year period (2007-2017). Articles that included the relevant key words were selected for their ability to answer the research objectives based on the information provided in the abstract. Selected articles were then categorised based on topic/working concept, and the extraction of data from each article was achieved through the interview process introduced above. However, due to incorporation of hermeneutics in the methodology, the literature review process essentially began with the initial background literature search. This initial search was not limited to peer reviewed journal articles of the last 10 years. The literature from this search formed the basic understanding of the issues at hand which provided the information in Chapter 2, and allowed for the identification of the four working concepts around which the literature analysis was structured.

[4] The *Discover* metasearch engine is powered by EBSCO*host,* © 2017 EBSCO Industries, Inc.

The key words used for the initial background literature review in the *Discover* metasearch engine were:

1) "Genetic engineering" OR "Genetically modified organism"
2) "Environmental ethics"
3) "Corporatization"
4) "Corporate social responsibility"
5) "Agriculture"
6) "Monsanto"

Each keyword was used in combination with each of the other search terms resulting in a total of 30 search phrases. For example: ("Genetic engineering" OR "Genetically modified organism") AND "environmental ethics"; ("Genetic engineering" OR "Genetically modified organism") AND "corporatization". The use of Boolean operators are a key concept within hermeneutics (Boell & Cecez-Kecmanovic, 2014). In this thesis, "AND" was the Boolean operator used most often as it was most important to find literature that combined the above concepts as opposed to excluding. Consequently, "NOT" was not used. However, "OR" was used with regard to incorporating both "genetic engineering" and "genetically modified organism" (GMO), as while GE is the preferred term used throughout this thesis, GMO is commonly used throughout the literature. The above six keywords/phrases were chosen due to their direct correlation with the subject matter identified by the aim. "Monsanto" was included in order to provide specific examples or case studies to illustrate the issues at hand.

The four working concepts that arose as a result of this background search were:

1) environmental ethics of GE;
2) environmental ethics of corporatization;
3) risk assessment; and
4) corporate social responsibility.

These topics, or working concepts, were selected because they effectively divided the literature into manageable categories that could each be addressed specifically in terms of their contribution to the overall research aim. In particular, it was necessary to separate the environmental ethics of GE from the environmental ethics of corporatization in order to establish the degree to which the two were interdependent while still approaching them separately. This was important in avoiding confusion and keeping the research objectives as the clear focus. For example, in much of the literature arguing against GE, the increased use of pesticides is referred to as a negative consequence of GE and hence a reason to oppose it. However, pesticide use is not a consequence of GE itself, but of the corporate application of GE in the creation of herbicide resistant crops. Consequently, the increased use of pesticides was categorized under the environmental ethics of corporatization topic group.

Risk assessment was recognized as being an important topic with regard to understanding how the risks of GE technology are understood and approached by those with differing perspectives on the technology, and the consequences of this for environmental ethics.

Once the above four working concepts were identified, “interview” questions were established in order to analyse the literature. These were:

1) Does GE breach environmental ethics? If so, how? And if not, why not?
2) Does the corporatization of agriculture breach environmental ethics? If so, how? And if not, why not?
3) Does the corporatization of agriculture affect the risk assessment process for GE crops?
4) What CSR practices are employed by GE agriculture corporations thus far with regard to GE in agriculture? What are the reported results in terms of environmental ethics when such practices are employed?

As a result of the understanding gained from the background literature search, additional key words were chosen for the subsequent searches in order to focus the literature analysis on providing answers to the above questions. These additional key words were:

1) “biodiversity”;
2) “integrity”;
3) “ecosystem health”;
4) “sustainability”;
5) “risk”;
6) “pesticides”;
7) “anthropocentrism”;
8) “technocentrism”;
9) “biocentrism”;
10) “ecocentrism”.

The keywords: “biodiversity”; “integrity”; “ecosystem health”; and “sustainability” were selected because they represented the primary areas of concern in the literature with regard to the environmental impacts of GE technology, corporatization and its associated pesticide use. These four keywords also represent aspects of the environment that are attributed intrinsic value according to the worldviews of biocentrism and ecocentrism. Consequently, in order ascertain whether the environmental ethics of these worldviews have been breached, their relative units of measure, such as biodiversity and ecosystem health, must be considered. The keyword “risk” was essential in incorporating issues surrounding the risk assessment process and the influence of corporatization, while the keyword “pesticides” was

essential in forming one of the key links between GE and corporatization with regard to the impacts of both on the environment. The key words: “anthropocentrism”; “technocentrism”; “biocentrism”; and “ecocentrism” were included in the search due to their role in the conceptual framework used. However the articles resulting from these key words were not incorporated until the discussion phase of the results. Each of these 10 additional keywords were searched in conjunction with “genetic engineering”; “environmental ethics”; and “corporatization” using the same Boolean operators: “AND”, and “OR”.

This search yielded 53 journal articles selected based on their title and abstract. Of these, 39 were used for the literature analysis while the remaining 14 articles were excluded based on their inability to directly contribute to the research objectives or specifically answer any of the interview questions upon further reading. For example, literature that focussed exclusively on the socio-economic aspects of GE and corporatization were excluded as the socioeconomic issues were outside of the scope of the research aim. As each piece of literature was selected, it was documented in an Excel spread sheet and alphabetized according to authors’ last names. Then, as each piece of literature was read in detail, notes were recorded in adjacent columns regarding stance, relevance and a summary of the overall argument. It is important to note that when articles were able to answer questions in multiple topic groups, they were included in all relevant groups. As each article was analysed, relevant answers to the ‘interview questions’ were highlighted. Once the analysis had been carried out, the results were considered within the environmental ethics framework of anthropocentrism, technocentrism, biocentrism and ecocentrism.

3.5. Summary

In this chapter, the research methodology that was used to carry out this literature analysis was outlined. The methodology was described and justified, followed by the steps that were taken to search for, categorize, and analyse the literature. The methodology of this thesis consisted of a RSLR including an interpretive approach within the paradigm of hermeneutics, beginning with a broader aim which was then refined as the investigation progressed. It then incorporated the “interview” technique described by O’Leary (2009) in order to extract the data relevant to each research objective, apply a critical analysis and develop the argument of the thesis. 39 peer-reviewed journal articles were selected for analysis, the results of which are presented in the following chapter.

Chapter 4 Results

4.1. Introduction

This chapter presents the results of the literature analysis. A total of 39 articles from 19 journals dated from 2007 to 2017 were analysed for their ability to answer the research questions for each of the four working concepts described in the previous chapter: the environmental ethics of GE, the environmental ethics of corporatization, risk assessment and corporate social responsibility. The *Journal of Agricultural and Environmental Ethics* contributed 15 articles while all remaining journals contributed one to three. A total of 18 articles were used to answer the questions relating to the environmental ethics of genetic engineering, 17 for the environmental ethics of corporatization, 13 for risk assessment and 7 for corporate social responsibility. As aforementioned, articles that were able to answer questions in more than one topic category were included in all relevant categories. The broad themes that emerged from the results were the importance of values in interpreting risks and benefits, and the resultant lack of consensus in the literature as a result of the two sides "speaking different languages" (Scott, 2015, p.838).

4.2. The Environmental Ethics of GE

This section of the results looks at the environmental ethics of genetic engineering technology itself, i.e. the process of deliberately inserting foreign genes into a selected organism, when applied to agricultural crops. The question asked is whether such a process breaches environmental ethics, and if so, how. Answers to this question were found to relate to different concepts within environmental ethics and the following section is divided as such. These concepts are biological integrity, ability to flourish, biodiversity and ecosystem health. The literature that was used to answer this question consisted of 18 articles, and are presented in Table 2 according to author, year of publication, and key argument:

Table 2. The environmental ethics of GE literature by author's last name, year of publication, and key argument.

Author(s)	**Year**	**Argument**
Bagavathiannan, Spök & Van Acker	2011	Perennial varieties, eg GE alfalfa, are particularly susceptible to adventitious presence making current regulatory processes inadequate. Coexistence policies are necessary.
Bennett et. al	2013	The economic and environmental impacts of agriculture can be summarised, and overall the net effect is positive. However, ethical issues remain controversial.

Gregorowius et al.	2011	Academic publications from 1975 to 2008 on the ethical implications of GE crops show the importance of considering virtue ethics.
Heink et al.	2012	The concept of environmental damage can be ambiguous and needs specific clarification. When considering biological integrity and ecosystem health, the argument for biodiversity is the only one that holds.
Kallhoff	2014	The concept of flourishing is useful in clearly identifying what impacts on a plant are beneficial or harmful and hence deserves moral respect.
Kaur, Kohli and Jaswal	2012	Life in its natural state has inherent dignity which is breached by GE. The release of transgenic organisms into an open environment is dangerous.
Myhr	2010a	While GE may result in short term benefits for the environment, there may be long term ecological consequences.
Myhr	2010b	The interactions between transgenes and ecosystems are complicated and could lead to unpredictable consequences. The concept of harm lacks a clear definition but biodiversity remains a strong argument.
Okada & Watanabe	2008	Genomes play a central role in biodiversity and ecological sustainability and intrinsic value should be respected.
Robaey	2016a	Owners of GE technology are morally responsible for the future unknown effects of their technology. However, the contamination of transgenes is unavoidable, resulting in loss of species and biodiversity.
Robaey	2016b	The ownership of seeds entails moral responsibility to avoid adverse effects on the environment. However, regulation buffer zones are inadequate in avoiding transgene contamination.
Rohwer & Marris	2015	“There is no prima facie duty to preserve genetic integrity”, but such a duty can be justified for the preservation of biodiversity.
Scott	2015	The cross-contamination of GE and non-GE crops is certain.
Scoville	2016	Ecological integrity should be included in the conservation of the environment.
Smyth & Phillips	2014	Contamination has occurred despite precautionary measures.
Timmermann	2015	Biodiversity should be conserved.
Timmermann & Robaey	2016	Species and biodiversity preservation are important for ecological sustainability. Many cultures ascribe biodiversity and species intrinsic value.

Verhoog	2007	Strong arguments against GE can be formed from the concept of integrity.

Biological integrity, the ability to flourish and ecosystem health are normative concepts that are regularly referred to in the literature when assessing the risk of GE in causing environmental harm and hence breaching environmental ethics. The literature varies in its respect for such concepts depending on the definitions used and values applied. Heink et al., (2012) argue against using the concepts to measure the environmental damage that occurs from GE crops due to their ambiguity in defining such damage. Rohwer and Marris (2015) agree that the use of the concept of genetic integrity is limited, but argue that concepts such as the right to flourish have firmer grounds. In contrast, Scoville (2016) provides a strong argument for integrity and a lesser one for ecosystem health. Scoville (2016) acknowledges the benefits to defending ecosystem health, but argues that since an ecosystem can be deemed healthy even if the integrity of its biota has been compromised, it is not as strict an argument as integrity. Meanwhile, Timmermann (2015) responds to Rohwer and Marris by arguing that while they discount the use of genetic integrity, all of their arguments can be used to justify the importance of conserving biodiversity. Furthermore, after Heink et al., (2012) discount the value of biological integrity and ecosystem health, they also conclude that the only strong argument for breaches of environmental ethics in their eyes relates to impacts on biodiversity. Consequently, when discussing the risk of GE to the environment, biodiversity is one of the most commonly referred to concepts throughout the literature. However, as the importance placed on each of these concepts are influenced by values, it is useful for the sake of this thesis to include the concepts of integrity, flourishing and ecosystem health as well as biodiversity.

4.2.1. Biological Integrity

The concept of biological integrity is used to argue that biological entities in their unadulterated form, i.e. unaltered through human interference, have an intrinsic value of their own, and hence moral standing. Integrity relates to both the elements and processes involved in the entity at hand (i.e. elements such as genes, and processes such as genetic expression), whether it be an individual organism, an ecosystem or both. It includes the concepts of evolutionary and genetic integrity and effectively argues that compromises of such integrity constitute harm. Scoville (2016 p.79) uses the definition of integrity that "refers to a property of landscapes that are relatively unmodified by human activity and that have their native biota largely Intact". Heink et al. (2012) refer to biological integrity as the "naturalness" of plants, species, communities and ecosystems, in terms of their natural evolutionary limits and ability to maintain a balanced and resilient system; thus, "the concept

of evolutionary integrity includes ensuring that the self-organization of the evolutionary process within the boundaries set by evolution is protected" (Heink et al., 2012). Finally, Rohwer and Marris (2015, p.234) describe genetic integrity as "that property which will disappear due to mixing of genes from another population". More specifically,

> 'genetic integrity' is commonly used in agriculture, conservation biology and ecology when the genetic composition of the organism, a community of organisms or even a whole ecosystem is in danger of being changed by the introduction of new genetic material – either by means of genetic engineering or, more naturally, by the presence of organisms with different genetic stock and the resulting transmission of foreign genes into the native gene pool. (Hauskeller, 2008, p.103 in Rohwer & Marris, 2015).

The justifications of valuing integrity within such definitions assume a degree of respect for natural processes such as evolution, and how such evolution has prepared ecosystems for optimal resilience. Gregorowius et al. (2011, p.277) argue that "[t]he intrinsic value of nature lies in the inherent safety mechanisms of natural evolution and these mechanisms would no longer function as an insurance against disastrous consequences if humans disturb them". Scoville (2016) provides a similar argument and explains that the integrity of a landscape should be respected for its ability to persist and withstand environmental fluctuations. He argues that evolution has resulted in the species that naturally populate an environment, and their ability to support the resilience of their ecosystem is why they should be protected. Within this context, Gregorowius et al. (2011, p.266) found that the modification of plants was deemed to be morally wrong if "regarded as an infringement of the integrity or dignity of plants or an interference with the natural order", the natural order being the key distinction. Similarly, Scoville (2016, p.82) argues that issues exist "[i]f the [GE] species in question displaces and adversely affects its native or naturalized neighbors". Finally, Verhoog (2007) notes that strong arguments against GE can be formed from a sound understanding of the philosophical and ethical principles of integrity, and consequently, proponents of organic agriculture reject GE on these grounds.

Heink et al. (2012) find fault however with the argument that compromising integrity constitutes harm, as it rests on the assumption that biological units such as species and communities have intrinsic value and hence moral standing. So, while GE plants are undeniably violating biological integrity, whether they are creating any harm in doing so is debateable. This is an issue of contention from an anthropocentric perspective. However, such assumptions are routinely adopted by bio and ecocentrists, and arguments from this perspective exist in the literature: Okada and Watanabe (2008) use the premise that the intrinsic value of the environment should be respected in order to justify appropriate CSR

practices surrounding genome management; Kaur, Kohli and Jaswal (2012) argue in favour of the intrinsic value of nature as a whole rather than a collection of individual and interchangeable genes; Timmermann and Robaey (2016) claim that many cultures and worldviews ascribe intrinsic value to biodiversity, seeing it as more than simply a resource, and; Gregorowius et al. (2011) found in their review of articles from 1975-2008 that while arguments for the intrinsic value of individual plants were few, intrinsic value was assigned to species, ecosystems and biodiversity.

Regardless of the applications of intrinsic value, the baseline of comparison has a significant influence on what is morally permissible. Scoville (2016) explains that the contamination of transgenic genes into a non-GE population would be classified differently depending on whether the baseline of comparison was “no disruption” or “acceptable disruption”. Heink et al. (2012) describe naturalness as the baseline of comparison for biological integrity and state that any interference with such integrity from its original, pre-human state constitutes a violation. However, they argue that “the violation of integrity does not necessarily equate to an adverse impact” (Heink et al., 2012). Others agree that the argument is not so black and white. Scoville (2016) argues that rather than assessing whether an organism complies with the original state of a particular ecosystem, a more pertinent question is how good a citizen the organism in question is to its community. This is significant given the argument that what originally would have been favourable to an ecosystem or community may not continue to be so in the face of climate change. For example, “[p]reventing anthropogenic changes to a genome merely because they are anthropogenic is... misguided and can lead to actions that many conservationists would deem counterproductive— such as when species adapting to a changing Earth are prevented from doing so” (Rohwer & Marris, 2015, p.245).

Consequently, it is challenging to find a concept of integrity that can be agreed upon given variable baselines of comparison and debates surrounding whether harm is caused if integrity is altered. However, the concept of integrity does have some use in recognizing the harms than can result from interference with the environment through the addition of transgenes if other concepts of value can be agreed upon. For example, while Rohwer and Marris (2015, p.234) conclude that when considered in isolation from other moral concerns, the preservation of genetic integrity does not stand, they argue that:

> if we do have a moral obligation to preserve genetic integrity in specific cases it is merely because doing so is a means (perhaps a necessary means) for fulfilling other possible duties, such as a prima facie duty to not impede individual flourishing.

Consequently, biological integrity should be valued as an instrument in a broader conservation aim with regard to avoiding harm.

4.2.2. Ability to Flourish and Ecosystem Health

While the concept of integrity is the subject of some debate as to its usefulness in establishing the moral implications of GE, the ability of an organism, species, community or ecosystem to flourish provides further grounds for an argument against GE. Unlike integrity, the concept of flourishing is useful in clearly identifying what impacts on a plant are beneficial or harmful (Kallhoff, 2014). Gregorowius et al. (2011, p.283) describe the value of flourishing as "the interest of the plant to develop and grow according to its species-specific characteristics, complete its lifecycle and flourish in a stress-free environment". According to Kallhoff (2014, p.688):

> A higher plant flourishes when:
> a) it is viable throughout its life, so that it is capable of reacting to external stress without endangering the overall performance which sustains its life;
> b) it is capable of accomplishing its typical life-cycle (juvenile phases and adult phases which end with proliferation);
> c) it succeeds in expressing the typical characteristics both of a plant which has a specific life-form and of a more specific organism, generally fitting its species description.

Kallhoff (2014) argues that GE has variable effects on a plant's ability to flourish, with some forms of GE hindering certain aspects and other forms supporting it. However, he notes that even when flourishing is supported by GE, there are likely to be unfavourable side effects. Furthermore, according to Kallhoff (2014) there is no debate as to the effect of GURTs on a plant's ability to flourish. He states that the technology "renders breeding either impossible or dependent on interventions from outside; it therefore… harms a living entity" (2014, p.698).

The concept of flourishing also relates to ecosystems as a whole, as an unhealthy ecosystem will not flourish. Ecosystem health is described as the resilience of the ecosystem in combination with its ability to provide ecosystem services such as nutrient cycling and pollination (Scoville, 2016). The health of an ecosystem and its ability to provide such ecosystem services ultimately depends on the health of the individual organisms within the ecosystem, of which plants are a significant component. Consequently, while ecosystem health may not be negatively impacted by altering integrity, as noted by Scoville (2016), a reduced ability of some plants to flourish would impact the resilience of the ecosystem as a whole.

4.2.3. Biodiversity

Just as a flourishing ecosystem is supported by the ability of its individual organism to flourish, it ultimately depends on biodiversity as an ecosystem cannot be supported by a

limited number of species. Much of the literature concedes that a central risk of GE application in agriculture is the risk to non-target organisms and the effects on biodiversity (Robaey, 2016b; Kaur et al., 2012; Timmermann, 2015), specifically, the contamination of non-GE crops and wild ecosystems via self-seeding and horizontal gene transfer (Robaey, 2016a). Robaey (2016b) argues that government regulations designed to prevent contamination through practices such as employing buffer zones, vary from country to country and hence do not prevent the spreading of GE seeds. Smyth and Phillips (2014) note a case of contamination of a neighbouring non-GE crop in Canada despite isolation measures having been implemented. Bagavathiannan, Spök and Van Acker (2011) state that the effective segregation of GE and non-GE crops can be expensive and inefficient, noting incidences of the contamination of human food chains with GE varieties that had not even been authorized for release. They note that contamination of transgenes into wild populations is inevitable, and that the possibility for retraction of such escaped genes is unlikely. Scott (2015, p.840) agrees, stating "if a GM crop is grown in a region with sexually related non-GM or organic crop some contamination is all but certain. It is not economically practical to keep crops in complete isolation." Such inevitable contamination is a point often left out by proponents of GE.

Genetic contamination has significant consequences for ecosystem health and biodiversity. The arrival of GE plants alters the genetic makeup of the resident species and the community as a whole, resulting in biodiversity loss (Robaey, 2016a). According to Kaur et al. (2012), such altering of genetic makeup can have significant consequences for evolution and result in the complete loss of certain traits and species. Timmermann and Robaey (2016, p.287) claim that the loss of some species that may appear unimportant from an anthropocentric viewpoint could have "catastrophic effects on an ecosystem". Myhr (2010b) along with Kaur et al. (2012) refer to the Cartagena Protocol in its specifications for protecting biodiversity with regard to the release of GE crops, and it's call for the precautionary approach to be utilized. Clearly, current application of the precautionary approach is inadequate in preventing genetic contamination.

As well as ecosystem health, biodiversity also plays a significant role in environmental and agricultural sustainability. Okada and Watanabe (2008) note the importance of biodiversity for sustainability, explaining that genes and genomes are the "origin of biodiversity" and are effectively responsible for the balance of ecosystems within the environment. Conversely, large agricultural monocultures are recognized by many as being less resilient to biotic shocks and pathogens than agroecosystems with a healthy biodiversity (Robaey, 2016a; Timmermann & Robaey, 2016). Timmermann and Robaey (2016) caution of the dangers of

genetic erosion resulting from large-scale monocultures and claim that in their heightened state of vulnerability to pathogens, greater doses of pesticides are required, further negatively impacting biodiversity through the effects of pesticides on non-target organisms.

While environmental ethics breaches are clear in the arguments above, it should be noted that others maintain the benefits of GE in spite of the drawbacks. Bennett et al. (2013,p.263) concede that the effects of some GE crops could affect non-target organisms, reducing the biodiversity of insects and birds, and that adoption of GE varieties "could result in the narrowing of genetic diversity of the crop itself". They also concede the presence of pesticide-resistant weeds and insects. However, overall they appear to argue against any breaches of environmental ethics, instead citing reduced pesticide use, increased yield/efficiency, reduced GHG emissions, and the consequent benefits for the environment and climate change of no-till or low-till farming practices. Finally, Myhr (2010a) is in favour of GE crops for their potential benefits for the environment but still notes the lack of scientific consensus on risks, particularly with regard to longer-term consequences which remain unknown.

In summary, while the literature is mixed with regard to the effects of GE crops on the environment, there are strong grounds for arguments against its application as a result of breaches of integrity, compromised flourishing and biodiversity. Whether or not GE itself is found to breach environmental ethics, the way it is applied affects the degree to which ethics are breached. Consequently, the corporatization of agriculture has significant implications for the applications of GE and their consequences for environmental ethics.

4.3. Environmental Ethics of Corporatization

This section of the results addresses the environmental ethics of the corporatization of agriculture, and the implications of this for the innovation and application of GE crops. If GE technology itself and consequently the application of GE technology in agriculture, is deemed to be a breach of environmental ethics, then anything designed to promote such application, such as corporate use of GE, is also breaching environmental ethics. However, the argument against the corporatization of agriculture still stands if GE is regarded as morally permissible, as the impacts of corporatization on the environment will depend on how GE is applied.

The corporatization of agriculture promotes the application of GE in agriculture through turning the previously public resource of seeds into a privately owned, profitable commodity,

restricting farmer options for the purchase of seeds to patented GE varieties. It fosters the innovation of crop varieties that require the purchase of associated corporate owned pesticides, increasing the application of chemical pesticides in agriculture. Meanwhile, the monopoly of the agriculture industry held by corporations results in constrained choice for farmers, which results in an increased likelihood of environmentally unethical practices. Finally, corporations are motivated first and foremost by maximising shareholder profit resulting in the innovation of cash-crops and profitable technology, hence taking priority over crops that may resolve environmental issues.

The literature for this section consists of 18 articles. Four were used with regard to the concept of corporatization specifically, 11 provided information regarding the effects of corporatization on pesticide use in GE agriculture, six referred to the monopolies that corporations hold of the agricultural input industry and six considered the ethics of IPRs. Table 3 presents the author name, year of publication, and the key argument for each of these 19 articles:

Table 3. The environmental ethics of corporatization literature by author, year of publication and key argument.

Author(s)	**Year**	**Argument**
Bagavathiannan et al.	2011	Perennial varieties of GE crops require extra use of non-glyphosate herbicide for stand termination and control of volunteer or rogue plants.
Benbrook	2012	Despite Bt crops reducing pesticide use, total use has increased due to herbicide resistant varieties and associated resistant weeds.
Bennett et. al.	2013	GE crops are related to herbicide resistance and effects on non-target organisms.
Biddle	2017	GE crops are not morally distinct from non-GE crops, hybrids can be patented.
Bronson	2015	The corporatization of agriculture was first enabled by hybrid seeds. GE followed, with corporate interests prioritizing profitable innovation over environmental wellbeing.
Busa & King	2015	GE provided useful criteria for the easy corporatization of agriculture.
Howard	2015	Seed contracts and the reliance on glyphosate/herbicides.
Kaur et al.	2012	IPRs favour large agrochemical corporations.

Kloppenburg	2010	The merging of firms reduces biodiversity.
Lemmens	2014	Corporatization should be considered separately from GE. They are not interdependent, GE could be beneficial if in the hands of the right people.
Leguizamón	2016	Corporatization has been a driver in distancing farmers from the farm resulting in ecological cost.
Perry, Ciliberto, Hennessy & Moschini	2016	Herbicide tolerant soybean and maize has resulted in increased herbicide use. Insect resistant maize has resulted in decreased insecticide use.
Robaey	2016b	Transgenic seeds come with contracts that require pesticide use.
Stuart & Schewe	2016	The production contracts that come with GE seeds result in farmers being pressured in unethical environmental practices.
Timmermann & Robaey	2016	Corporatization prioritizes profits over environmental welfare..
Wilson	2007	The patenting of GE crops cannot be morally justified.

4.3.1. Corporatization

Busa and King (2015) analysed the criteria that result in a situation or movement being susceptible to corporatization. In particular they note the presence of 'materiality' "meaning there is an easily commodifiable component or the potential for a scientific or technological fix", and that "some of the most extreme cases of corporatization seem to occur in movements connected to environmentalism" (Busa & King, 2015, p.252). This clearly describes the way in which GE allowed for the 'technological fix' of issues such as climate change and food security, while also providing the means for commodification through the patenting of seeds. Furthermore, the corporatization of agriculture would not have been so successful had there not been the opportunity to exploit the need for climate change mitigation and food security, representing the environmental movement component. Consequently, it can be argued that GE has a served as a tool in the corporatization of agriculture.

Such corporatization has implications for the environment. In keeping with the argument above, Lemmens (2014, p.135) argues that "genetic engineering technologies ideally enable the capitalist penetration of agriculture and the conversion of farming into a wage-labour activity, thereby transforming the farmer into a proletarian". Once the farmer has taken on the role of the proletarian, his role as steward of the environment is compromised and such

stewardship, for better or worse, is in the hands of the owners of the GE technology. Lemmens (2014, p.135) explains that:

> [w]ith biotechnology becoming prevalent, the care and responsibility for the living is more and more transferred from farmers to biotechnologists…The problem is that, today, these biotechnologies are everywhere turned into private property - through aggressive intellectual property legislation - by big agrotech multinationals, with the principle aim of acquiring monopolies and ensuring profits, *not* of providing farmers with new innovative breeding tools… it is this corporatization of agriculture… that represents the biggest threat to the knowhow of farmers and to the care and responsibility for the living accompanying it.

This represents a transition away from the stewardship of the land which farmers traditionally practiced, to a relationship which is out of touch with the needs of the land and consequently exploitative.

Others share such views including Leguizamón (2016) who describes agribusiness as disconnecting and "abstracting" agriculture from its "natural origins", instead becoming knowledge-based and independent of environmental conditions. Bronson (2015) describes the journey from farmer-led innovation in plant breeding to the gradually more privatised innovation of hybrids, finally resulting in almost exclusively corporatized GE crops. Although referring predominantly to Canadian agriculture, he argues that "GE seed systems were co-produced with a techno-scientific infrastructure favouring productivist interests and corporate farming" (Bronson, 2015, p.62). Consequently, Bronson (2015, p.62) backs up Lemmens (2014) in stating that:

> With the slow institutionalization of plant breeding into scientific laboratories over the mid-twentieth century, farmers lost their primary position as innovators in the breeding process and, over time, the locus of power shifted from farmers conducting experimentation according to community needs and in operational farm fields, to experimental field trials and laboratory testing.

Such privatisation has significant consequences for the environment as corporate interests take priority over environmental sustainability (Bronson, 2015). Busa and King (2015, p.251) note the likelihood of large corporations "externalizing costs onto workers and the environment" in the pursuit of profit, and that,

> for decades, scholars have been pointing to the negative implications of the corporatization of North American agriculture for farmers and the natural environment.… At the same time, government advice and agrichemical corporations have historically been (and continue to be) aggressive in promoting technological innovations as solutions that will 'make the farm pay'. (Bronson, 2015, p.69).

Furthermore, the adoption of GE by agrochemical corporations is seen by some as a strategic move to dominate a market that was slipping from corporate grasp. Bronson (2015) explains how GE was adopted in part as a solution to the profit drops that resulted from farmers stepping away from hybrid seeds when their chemical counterparts became too expensive after the Green Revolution. Chemical corporations responded by rebranding themselves as Life Sciences corporations and redirecting their innovation to GE seeds, specifically herbicide resistant varieties (Bronson, 2015). The commercialization of GE crops proved to be 100 times less expensive, and consequently much more profitable, than the development of new pesticides (Bronson, 2015, p.71). The focus on herbicide resistant varieties maintained the significant profit margin obtained from pesticide sales, as Bronson notes: "By 1999, only two decades after the pesticide corporations had entered the biotechnology sector, 78% of all GE crops planted in the world were engineered for proprietary herbicide tolerance" (2015, p.71). The dominance of Life Sciences corporations over agriculture was then secured through the patenting of such seeds (Bronson, 2015).

The commodification of GE seeds and their respective chemical counterparts would be less concerning if the result wasn't such a step away from traditional farmer practices and ethics. "In their advertisements, the former agri-chemical corporations like Monsanto and Dow Crop Sciences have consistently offered their products as technologies that will allow a farmer to 'clean' his/her field of weeds" (Bronson, 2015, p.71), a concept which arguably does not aid in promoting a symbiotic relationship with the environment or the preservation of biodiversity. Consequently, a significant characteristic of corporatization of agriculture through GE has been the reliance on pesticides.

4.3.2. Pesticides

The pairing of herbicide-resistant seeds and synthetic chemical pesticides has led to the use of pesticides becoming irreversibly entwined with the GE argument. Regardless of whether GE technology itself is hazardous for the environment, the corporatization of agriculture goes hand in hand with a reliance on pesticides and hence a sound argument against corporatization can be formed simply through demonstrating the adverse environmental effects of such pesticides. Monsanto's herbicide resistant varieties, RR crops, depend on the herbicide Roundup© to achieve their stated efficiency and yield potential (Howard, 2015). Furthermore, most transgenic seeds come with contracts which require the purchase of such pesticides (Howard, 2015; Robaey, 2016b). The fact that RR crops and Roundup© are both produced by Monsanto increases the potential for corporate profit while tying farmers to a pesticide with known consequences for non-target species, specifically pollinators (Howard, 2015).

A significant issue results from the increasing amount of pesticide found to be necessary for GE crops. RR crops typically require increasing doses of Roundup© in order to stay one step ahead of increasingly resistant weeds. This is a significant strategy for Monsanto's global dominance in terms of overcoming country specific variations in regulation. For example, the patenting laws of the U.S. do not extend to Argentina, allowing Argentinian farmers to continue their seed saving practices (Leguizamón, 2016). This means that while Argentina's soy industry is less profitable than Brazil and the U.S. due to its seed market consisting of largely saved and black-market seed, GE crops remain profitable for Monsanto due to the growing sales of glyphosate, a necessary input for RR soy (Leguizamón, 2016). Bronson (2015, p.71) claims that Monsanto's GE soy "pushed sales of its herbicide glyphosate (Roundup©) to extreme levels of profitability in the late twentieth and early twenty-first centuries".

Robaey (2016b), Benbrook (2012), Bennett et. al. (2013), Timmermann and Robaey (2016) Kaur et al. (2012), and Perry et al. (2016), all note the issues of herbicide resistance, the increased use of pesticides and the consequences for biodiversity. Specifically, Benbrook's (2012) study found that while insecticide use was reduced in response to Bt crops, herbicide use significantly increased as a result of herbicide tolerant crops. "The magnitude of increases in herbicide use on herbicide-resistant crops has dwarfed the reduction of insecticide use on Bt crops… and will continue to do so for the foreseeable future", primarily due to herbicide-resistant weeds (Benbrook, 2012). Perry et al. (2016) agree that while Bt crops have resulted in a decreased use of pesticide, herbicide use has gradually increased for herbicide resistant crops in response to herbicide resistant weeds. Benbrook (2012) also notes that increasing incidences of insecticide-tolerant insects threatens the long term viability of Bt crops and makes increased applications of insecticide likely. Consequently, the agrochemical industry's claim that GE crops result in the reduction of pesticide use has not proved to be the case.

Herbicide resistant crops also encourage the excessive use of pesticides even before resistant weeds have emerged due to their allowance for the practice of spraying the entire crop as opposed to targeting specific areas. This is concerning from the perspective of non-target organisms and biodiversity, yet other environmental effects triggered by the increasing quantities of pesticide used are also significant. For example, "Glyphosate has been shown to impair soil microbial communities in ways that can increase plant vulnerability to pathogens... while also reducing availability of certain soil minerals and micronutrients", reducing water use efficiency and nitrogen fixation (Benbrook, 2012, p.6). Benbrook (2012, p.6) argues that "[l]andscapes dominated by herbicide-resistant crops support fewer insect

and bird species" and that collectively, such effects "raise novel concerns over long-term, possibly serious impacts on biodiversity, soil and plant health, water quality, aquatic ecosystem integrity, and human and animal health".

The presence of herbicide resistant weeds and the increasing amounts of herbicides needed to combat them is therefore a common argument made against GE in the literature. It is important to note that such resistant weeds and pesticide use are more a result of corporatization and the preference given to cash crops, than GE itself. It is acknowledged in the literature that the competitive nature of corporations results in innovations in GE revolving around profitable traits as opposed to traits that may actually resolve environmental issues (Howard, 2015). Timmermann and Robaey (2016) describe the way corporatization affects priorities through the focus on profit-maximization creating "ecologically disastrous incentives" in GE and pesticide product development. Notably, there are also those such as Lemmens (2014) who argue in favour of GE technology, but only if it is not under the control of multinational corporations whose sole purpose is the pursuit of profit.

Furthermore, the competitive nature of the corporate world means that economic growth remains the priority and results in innovations which may have increased environmental risk. Stacked GE traits push the boundaries of biological integrity even further than single trait GE seeds, while the introduction of perennial GE varieties adds a layer of risk in terms of gene flow. Howard (2015) notes that as stacked traits become more common, farmers may have no choice but to purchase seeds with stacked traits even they only require one of the traits present. Meanwhile, the cultivation of perennial GE crops such as glyphosate resistant alfalfa results in the increased use of harmful, non-glyphosate based herbicides due to the need for stand termination, the destruction of the crop upon expiration of the GE seed contract, together with the need to control 'volunteers'[5] and escaped/feral populations (Bagavathiannan et al., 2011). Such competitiveness may be less of an issue if there were enough firms present in the industry to create genuine competition. However, over the years, mergers of corporations have increasingly reduced the number of firms involved in agricultural biotechnology. For example, Bayer Crop Science acquired two Argentine seed and technology companies in two successive years, resulting in reduced competition and increasing monopolies (Leguizamón, 2016).

[5] Volunteers are plants that germinate on arable land from stray seeds from the previous season.

4.3.3. Monopoly

The effects of corporatization are intensified by the dominance of a few agrochemical corporations and their resulting monopolies of the industry. For example, just as the corporatization of agriculture exacerbates pesticide use, monopolies result in biodiversity being further compromised, together with farmer choices becoming limited and farm practices becoming increasingly controlled by corporate models. Kloppenburg (2010) argues that biodiversity is compromised by the consolidation of seed firms. As fewer firms dominate the seed market, fewer seeds and hence fewer genetic resources are available to farmers, and a higher proportion of the seed market then consists of patented GE seeds as opposed to non-patented conventional seeds (Howard, 2015). Timmermann and Robaey argue that a "variety, even if leading to higher yields, should not become so dominant that it disincentivizes the seeding of other varieties" as such a monopoly results in genetic erosion (2016, p.289).

This lack of diversity in corporate-owned, market seeds is exacerbated by the corporate style of agriculture, typically large monocrops. The dominance of corporate seeds on the seed market results in the "expansion of unsustainable monocultures… that too often contaminate other varieties with proprietary transgenes" (Kloppenburg, 2010, p.372). Timmermann and Robaey (2016) together with Leguizamón (2016) note the dominance of extensive GE monocultures in South America being the cause of socio-ecological issues. For example, Argentina is the 3rd largest producer of soy in the world after the US and Brazil, with 100% of its soy being GE (Leguizamón, 2016). Consequences for the Argentinian environment as a result of this include "deforestation, soil nutrient depletion, and water, air and soil pollution" (Leguizamón, 2016, p.315). Leguizamón (2016, p.326) further claims that the GM soy model is "undermining the sustainability of the environment" through labour-replacing technologies increasing the reliance on fossil fuel and chemical based practices.

The monopoly held by seed companies also limits the choices available to farmers with regard to their farming practices through tying them to production contracts. Stuart and Schewe (2016) argue that such contracts tie farmers to a competitive farming practice whereby they are rewarded for increased yields, and within which environmentally friendly practices are not supported (Stuart & Schewe, 2016). They found that such contracts "create structural barriers that constrain management decisions and inhibit the development of a climate change ethic among farmers" (p.370). The contracts "dictate farming practices, constrain choices, and result in situations where farmers feel they have to contribute to environmental degradation and that they cannot participate in environmental practices and programs that would reduce degradation" (Stuart & Schewe, 2016, p.370). Similarly,

Bronson (2015) notes that often, once a farmer experiments with GE agriculture, he will be forced to stay with it as a result of the legal framework surrounding GE crops and the persistence of genetic material on the land. As a result, the common argument made by proponents that the high adoption rates of GE agriculture represent farmer satisfaction with the technology, may be more a result of their inability to revert back to non-GE agriculture once GE has been introduced (Bronson, 2015).

4.3.4. IPRs

Finally, in countries such as the U.S., Canada and Brazil, the corporatization of agriculture allows for the patenting of GE seeds which has numerous consequences. For example, IPRs restrict the practice of seed saving (Howard, 2015; Kloppenburg, 2010) and hence reduce biodiversity (Timmermann & Robaey, 2016), the patenting of crop seeds privatizes sections of the agricultural gene pool that previously would have been a public resource. While many of the arguments surrounding IPRs are with respect to social implications (eg. Kaur et al. 2012; Wilson, 2007), they can be applied to the environment in a similar way to the corporatization argument; if GE crops are deemed unethical, then anything that promotes their use, such as IPRs, are also unethical. Although, as Wilson (2007) points out, for the ethics of GE crop patents to be considered in their own right, the assumption must be made that GE crops are in themselves morally permissible; if GE crops are deemed unethical, then it would automatically follow that patents on GE crops would be unethical. Consequently, the ethics of patenting are considered separately, under the assumption that GE crops are ethical.

Wilson (2007) explains that the presence of patents is justified by the assumption that without such protection of intellectual property, there will not be enough incentive to innovate and society will lose out on the potential benefits of such innovation. However, this justification fails as, broadly speaking, Wilson (2007) explains that such hindrances to innovation don't necessarily exist in the absence of patents and sometimes, the patents themselves may be counterproductive to innovation through limited information sharing. Wilson (2007) concedes that removing the patents of GE crops may initially slow innovation, but as he argues in favour of GE agriculture, he claims that a slower rate does not mean an inadequate rate, and that slowing down the rate of innovation in the case of GE crops may be a good thing if it allows the public acceptance of GE to improve. From the perspective of environmental ethics, a slowed rate of GE crop innovation with greater participation from the public sector could result in more appropriate risk management strategies, and an increased focus on environmentally sustainable practices (Wilson, 2007).

Biddle (2017) notes that it is not just GE crops that can be patented, but also some varieties of hybrids, therefore, it is not necessarily the patents that are the issue, but who holds them and the consequent contracts and restrictions that accompany them. Biddle (2017) predicts that if there was more public funding for GE technology and the patents of GE seeds were held by public entities, then such restrictions and contracts would most likely be relaxed. Biddle (2017, p1) suggests therefore that "the most important question that we should be asking is not whether a technology is GE, but whether it is responsibly designed". A majority of the literature, regardless of the positioning with respect to GE, agrees that when in the hands of corporations, such responsibility is lacking. According to Biddle (2017, p.6):

> [w]hat is needed are guidelines for helping to distinguish between those crops that contribute significantly to important humanitarian goals and those that do not – whether or not the crops are GE. Such guidelines should go beyond mere technical effectiveness and include broader considerations, such as whether a crop will contribute to sustainability and whether it will be affordable and/or accessible to those who most need it. Many of the most important criticisms of GE crops, again, do not focus on technical potential, but rather upon broader ethical and socio-economic considerations.

Consequently, the environmental ethics of IPRs on GE seeds ultimately depends on the corporate agenda at hand, and how such IPRs are applied.

In summary, there are multiple grounds for arguing against the corporatization of agriculture from the perspective of environmental ethics. Ultimately, as a result of corporations being businesses, their priority will always be the increasing of shareholder profit, at the expense of environmental wellbeing. This is clear through the corporate pairing of pesticides and GE crops, the focus on cash crops as opposed to varieties that would genuinely benefit the environment, the restrictions that farmers face in their farming practices as a result of seed contracts and IPRs, and the monopoly that corporations hold over the agriculture industry.

4.4. Risk Assessment

The degree to which the corporatization of agriculture through GE breaches environmental ethics depends both on the risk that GE poses to the environment, together with how such risk is assessed and mitigated. Consequently, this section reports on the consequences for the environmental ethics of corporations being involved in the risk assessment process and their influence on its reliability and transparency. The literature used consists of 13 articles, most of which are in agreement that the primary weakness in the risk assessment of GE crops is the focus on objective criteria and scientific research, while not including consideration of ethics and values. Values such as those held by biocentrists and ecocentrists are inherently involved in the recognizing and understanding of risk, due to

differing views on what should be protected and why. Consequently, the controversy surrounding GE will not be resolved until such values are incorporated into the risk assessment process. Table 4 lists the 13 articles used in this section, by author, year and key argument:

Table 4. Risk assessment literature by author, year of publication and key argument.

Author(s)	**Year**	**Argument**
Gerasimova	2016	There is no consensus as to the effects of GE crops on the environment, sustainable development is used to argue both in favour of and against GE. The sides will never meet in understanding as long as different values are held.
Hubbard & Hassanein	2013	The precautionary approach should be included in the regulatory review processes of GE crops.
Kvakkestad, Gillund, Kjolberg and Vatn	2007	Scientists' views are heavily influenced by whether or not they are employed by the agrochemical industry or have a background in ecology when making decisions surrounding risk assessment.
Mampuys & Brom	2015	Proponents of GE believe current risk assessment processes are adequate, opponents believe they are not. The controversy is represented by the presence of "alarming studies".
Meghani	2014	Agrochemical corporations are biased in favour of their product when carrying out risk assessment.
Meghani & Kuzma	2011	The flow of personnel between agrochemical industry and government regulatory agencies gives industry an unfair advantage.
Myhr	2010a	Controversy surrounds application of the precautionary principle. The argument needs to be less polarized. The solution is to widen the pool of considerations in risk assessment and to include public participation.
Myhr	2010b	Application of the precautionary principle is resisted by GE proponents. Consequently, there is controversy in how to appropriately assess risk.
Resnik	2015	Journal editors should be bound by strict guidelines with regard to retracting publications. The Séralini publication was retracted without strong grounds to do so. Implications of conflicts of interest exist.
Robaey	2016a	The risks of GE crops are unknown and unpredictable.
Scott	2015	Both sides are "speaking different languages" as the debate is ultimately over values.

Smyth & Phillips	2014	The EU's risk assessment process has become too politicised, restricting "safe" GE foods, and in doing so increasing food insecurity.
Verhoog	2007	The organic movement rejects GE based on the unacceptable level of risk and uncertainty involved as a result of a rejection of reductionist principles.

In order to ascertain whether any breaches of environmental ethics are present as a result of the corporatization of GE agriculture, it would be useful to establish whether there is a consensus in the literature as to the actual risk of GE to the environment. However, the only consensus that exists is that the degree of risk is unknown and the future consequences of releasing transgenes into the environment cannot be predicted (eg. Robaey, 2016a).
With regard to other aspects of the risk assessment, the argument is polarised. Those in favour of GE, notably the biotechnology industry, argue that current risk assessment and regulatory procedures are adequate, while those concerned about GE argue the opposite, that further, more rigorous testing needs to be carried out (Mampuys & Brom, 2015). Scientists are present in both camps, in favour of and against the release of GE crops into the environment (Gerasimova, 2016), making it clear that the argument is not simply a case of scientists versus the lay public as has been the presentation by some proponents of GE.

The unpredictable nature of GE and the degree of unknown risk involved forms a common theme in the literature. According to Verhoog (2007), the organic movement's rejection of GE is centred on the unpredictability of the technology and consequently the unacceptable level of risk involved. He lists the risks of GE as resulting from:

1) "The low efficiency rate of the technology";
2) the "trial and error process" by which the synthetic genes are constructed;
3) the unpredictable effects of introducing foreign DNA and;
4) the "belief in genetic determinism" stemming from a reductionist philosophy that doesn't take into account the myriad other factors involved in gene expression (Verhoog, 2007, p.389).

This is in keeping with Robaey's (2016a) argument, particularly her description of owners of GE technology as experimenters given the degree of unknowns involved. Such unpredictability makes the risk assessment process of GE crops all the more important.

The risk assessment process itself is also bound by controversy. Meghani (2014, p.968) found that the corporatization of agriculture instils a bias in the priorities of risk assessment measures and argues that "individual biotechnology companies and the industry as a whole

may focus primarily or solely on the benefits of the products rather than being appropriately attentive to their adverse impact". This may explain the reluctance of GE proponents to include the precautionary principle in risk assessment procedures. Hubbard and Hassanein (2013) argue that there is a need for a precautionary approach to be included in the regulatory agencies' reviews of GE crops and notes that currently, [unlike in the EU] the approach is not a common component of U.S. law. According to Myhr (2010b), the application of the precautionary principle to GE has been supported by those against GE but resisted by GE proponents.

> The risk assessment of GM crops has resulted in different policy outcomes dependent on how the regulatory agencies involved have acknowledged scientific evidence as well as the associated uncertainties. This has caused disagreements about the significance of scientific evidence on benefits and risks and the appropriateness and necessity of risk frameworks and regulation. Especially, the role of precaution in risk assessment and management processes of the commercial use of GM crops and GMOs in general has caused controversy.(Myhr, 2010b).

Others note the presence of a clear bias in favour of the agrochemical industry as a result of corporate funding and the flow of personnel between industry and regulatory agencies. Kvakkestad et al. (2007) found that scientists' views were heavily influenced by whether or not they were employed by the agrochemical industry or involved in ecology. Unsurprisingly, all those who viewed GE as beneficial and of low or no risk were employed or funded by the GE industry, while all those in opposition were ecologists and/or publicly funded scientists (Kvakkestad et al., 2007). Meanwhile, Meghani and Kuzma (2011) describe the movement of personnel between government regulatory agencies and industries. They argue that the presence of industry personnel in government regulatory agencies results in an undermining of the democratic process, giving industry an unfair advantage and compromising adequate risk assessments of GE technology. Though this argument refers to the U.S., such flow of personnel can occur in any democratic country, and arguably would be less of an issue if there were no corporate interests in GE technology. Such findings question the reliability of risk assessment due to the clearly vested interests held by the agrochemical industry.

Smyth and Phillips (2014) are an example of GE advocates who believe the current risk assessment procedures are more than adequate. They argue vehemently in favour of GE technology for its ability to contribute to solving global food security issues, claiming that in applying stricter regulations than North America on the use of GE crops, the EU is promoting food insecurity. They state that due to the inclusion of socio-economic considerations in their risk assessment, the process is no longer objective and has been politicized. Smyth and

Phillips (2014, p.171) argue from the premise that "science-based risk assessment" renders GE food safe. Furthermore, they claim that in contrast to the EU, North America's regulatory decisions are "predictable and efficient" (2014, p.170), a claim that would clearly be rebuffed by many who argue that it is this very objectivity and lack of value inclusion that renders the U.S.'s risk assessment process inadequate.

The controversy surrounding risk and the adequacy of GE regulation is further demonstrated by debate surrounding so-called 'alarming studies', as described by Mampuys and Brom (2015). Alarming studies raise doubt about the safety of GE crops and the adequacy of their safety testing (Mampuys & Brom, 2015). One example of an alarming study was that of Séralini et. al.'s (2012, as cited in Mampuys & Brom, 2015) long term rat feeding trial which assessed the effects of GE transgenic maize and Roundup©. Séralini et. al. (2012, as cited in Mampuys & Brom, 2015, p. 906) "concluded that the rats fed with GM maize and herbicide developed more and more serious tumors than the control group". Published in *Food and Chemical Toxicology* (FCT), the study attracted criticism and was retracted without the authors' consent in 2014 on the grounds of inconclusive research, but was later republished by *Environmental Sciences Europe* with a response from the authors (Resnik, 2015). Both those who criticised the article and the article's authors were accused of having conflicts of interest (Resnik, 2015). Regardless, Resnik (2015) concludes that the editors of FCT should not have retracted the article without stating a more justifiable reason than it being inconclusive, given that they found no fraud or falsification in their review of the study.

Controversial studies will remain so, and are unlikely to be resolved through the standard call for more research according to Mampuys and Brom (2015), unless the framework for discussion is widened to incorporate different values. Similarly, Myhr (2010a) argues that resolution to controversy is typically sought through further scientific research, which, aside from bringing to light further areas of uncertainty, fails to address the core problem that the different sides are arguing from different perspectives and incorporating different values. Others also argue that it is the inclusion of different values that divides the argument (Gerasimova, 2016; Scott, 2015) and as long as the opposing sides argue from the perspectives of different worldviews, a consensus will never be reached. Gerasimova (2016) describes the GE debate through the lens of sustainable development, noting that both sides are arguing in favour of sustainability, biodiversity and food security, often using the same argument, while Scott (2015) notes that both sides are "speaking different languages". "The scientific risk assessment may deal with the safety issues, but interest-based, value, moral and worldview disagreements play an important role in the discussion about GMOs as well" (Mampuys & Brom, 2015, p.904). Myhr's (2010a) solutions focus on the inclusion of more

participatory risk assessment processes whereby the public are included. However, the likelihood of such a shift appears unlikely.

Overall, the risk assessment process is marked by much controversy due to the polarity of the arguments for and against GE, and the different values included. Such controversies will not be resolved until a broader range of values are included in the debate. Whether corporations are willing to genuinely incorporate such values is ultimately the deciding factor in determining the effect that the corporatization of agriculture has on the risk assessment process of GE crops. It appears that as long as corporate profit remains a priority, risk assessment processes will be unreliable. As a result, the environmental ethics of corporatization has much to do with how agrochemical corporations adopt and employ CSR.

4.5. Corporate Social Responsibility

This section assesses the literature with regard to CSR practices that have been employed by corporations and what the results have been in terms of environmental ethics. Monsanto is used as an example with regard to the CSR practices that it has employed and their reception due to its dominance of the industry and association with controversy (Charlebois & Van Acker, 2015). Seven articles were included in the analysis on corporate social responsibility, as listed in Table 4. Two articles include more in depth examples of CSR projects, the *Water Efficient Maize for Africa* (WEMA) in which Monsanto participated, and Monsanto's *Smallholder Program* (SHP). Two further articles provide brief examples of Monsanto's application of CSR. The remaining three articles provide generalized CSR examples and their relative successes. Table 5 lists the articles used in this section by author, year and argument:

Table 5. Corporate social responsibility literature by author's last name, year of publication, and key argument.

Author(s)	**Year**	**Argument**
Bazin	2009	The environment should be considered a stakeholder that can undergo harm as a result of corporate action.
Benbrook	2012	Monsanto's scientists were involved in publications assuring the safety of glyphosate resistant crops and the unlikely event of resistant weeds resulting.
Biddle	2017	Monsanto's participation in WEMA.
Clapp	2008	Illegal GE crop releases pose environmental risk and are examples for failed voluntary CSR.

Glover	2007	Monsanto's Smallholder Program was a CSR initiative with a mixed agenda.
Hubbard & Hassanein	2013	Monsanto demonstrated lack of transparency in their disclosure of GE alfalfa field trials.
Okada & Watanabe	2008	Biotech corporations' practicing of CSR that is appropriate to the specific nature of genomes is inadequate.

The WEMA project is an example of a "public-private partnership" that began in 2008 (Biddle, 2017). Led by the African Agricultural Technology Foundation which functions to coordinate such partnerships, it has the aim of increasing food security in sub-saharan Africa (Biddle, 2017). Though it's motivation is primarily social, it can be argued that increasing water efficiency has environmental benefits due to the global water shortages as a result of climate change. Consequently, it can be used as an example of a CSR practice with regard to environmental ethics.

Monsanto has been a participant in WEMA through "offering agricultural expertise, technological know-how, and royalty-free access to its drought-tolerant and insect-resistant traits" (Biddle, 2017, p.10). However, Biddle (2017) claims that the project is still too young to gauge any concrete impacts, positive or negative. He uses the WEMA project as an example of what "responsible research and innovation" might look like if it were to be employed as a concept by agrochemical companies (p. 2). This raises questions as to why there are not more appropriate previous examples that could have been used to demonstrate such responsible innovation despite GE technology being decades old. The specific seed varieties involved are designed to tolerate abiotic stresses that could result in significant advantages for resource poor farmers in light of climate change (Biddle, 2017); but, this is not an achievement that can be celebrated until such benefits have been unanimously experienced by those in need. Furthermore, the project has been controversial. According to Biddle (2017, p.11) the African Center for Biodiversity opposes the WEMA project on the grounds that it is promoting a system of agriculture that is not necessarily suited to or beneficial for small-holder farmers, given that it is a system focusing on technological solutions and "sustainable intensification" as opposed to a democratic participation model with a food sovereignty emphasis.

Monsanto's SHP provides another CSR example. Investigated by Glover (2007), it began in 1999 and ended in 2002 with limited success. The SHP was designed to provide poor smallholders with all of the inputs and training necessary for the implementation of Monsanto's GE agriculture. It involved a representative of Monsanto living in a village,

delivering recommendations on the correct utilization of Monsanto's products while advocating for the benefits that they could bring, providing free samples of seeds and chemical inputs, after which the products were sold at normal price (Glover, 2007). Glover's research found though that the communication with the villagers was inadequate and vague. Small holders often had no prior knowledge of the arrival of the representative or what his purpose was, and were given no choice as to the training provided. Many of the projects lasted little more than two years and ended without clear communication with the smallholders, leaving them confused as to what could be expected or the degree to which Monsanto could be held accountable.

A specific issue of the SHP identified by Glover (2007) was Monsanto's selection process for the villages and smallholders which was based less on the degree to which the farmers could benefit from the new technology, and more on the convenience of accessibility, access to infrastructure and potential for market growth. For example, one region of India was chosen purely as a result of its low proportion of hybrid varieties, thus offering a significant potential for the adoption of Monsanto's varieties. Monsanto representatives noted that often the smallest farms were not able to adopt the technology due to the high start-up costs, while criteria for participant farms included the willingness to take on loans in order to cover such start-up costs. Finally, villagers reported that both large and small farms were adopted into the program but that farmers weren't treated equally, with special treatment given to those with greater capital, ranking or status. Glover (2007) concludes that while on the surface it appeared that the SHP was motivated by genuine humanitarian goals, the reality was that Monsanto struggled to combine its business goals with a philanthropic nature.

Aside from CSR projects, Clapp (2007) raises the important issue of the effectiveness of CSR in its current voluntary capacity. In particular the U.S. requires that firms report on their legal compliance rather than using a command and control method. Clapp (2007) refers to the three incidences of illegal release of unapproved crops, all in the U.S. and which all resulted in contaminations of global food chains. As Clapp (2007, p.348) explains, "[w]hile CSR... encourage[s] internalization of environmental costs and application of the precautionary principle amongst firms, in the case of illegal GMO releases these measures have proven extremely weak". Consequently, it appears that voluntary CSR measures will not suffice in ensuring appropriate environmental responsibility.

Finally, the principle of CSR is not necessarily restricted to specific projects with beneficial outcomes for society or the environment. The concept of CSR demands that the everyday practices of a corporation, at the very least, do no harm. Bazin (2009, p. 635) argues that "it

is the responsibility of companies to care for the preservation of nature" and that the environment should be a considered a stakeholder, capable of being harmed as a result of corporate action. Meanwhile, Okada and Watanabe (2008) justify the need for a new CSR component that specifically deals with the responsible use of genomes. They argue that "biotechnology companies' efforts to embody so-called 'genome-conscious management'... are inadequate" so far (2008, p.152).

There are numerous examples throughout the literature of Monsanto's everyday practices compromising environmental ethics, regardless of the virtues of their CSR projects. For example, a lack of transparency lead Monsanto to retain statistics of its RR alfalfa field trials as a trade secret, preventing regulatory agencies from carrying out adequate risk assessments and raising questions as to the threat of contamination (Hubbard & Hassanein, 2013). Papers by Monsanto scientists in the 1990s stated that glyphosate tolerant weeds were highly unlikely to be an issue in response to glyphosate tolerant GE crops (Benbrook, 2012); this has since been proven wrong. Monsanto has a history of assuring the safety of products that later prove otherwise, for example, dioxins such as Agent Orange and polychlorinated biphenyls (Glover 2007).

In summary, literature on the CSR of agrochemical corporations from the last 10 years with regard to environmental responsibility is limited. A much greater amount has been published with regard to the social aspects of CSR, particularly with regard to IPRs and the food sovereignty in developing countries. Agrochemical corporations have made moves to aid resource poor farmers in developing countries, for example through providing royalty free seeds in WEMA. However, other CSR initiatives such as the SHP placed no priority on environmental sustainability, leaving substantial gaps in the CSR of such corporations. It is considered that CSR as a principle should go beyond specific projects and demand responsibility in the day to day practicing of corporations.

4.6. Summary

While there are contrasting opinions as to the environmental ethics involved in the practice and application of GE, and the corporatization of agriculture, there is enough evidence in the literature to form a strong argument against such corporatization due to the environmental ethics that are compromised. Whether or not GE agriculture in its own right is in breach of environmental ethics, it is clear that the corporate control of agriculture compromises risk assessment and regulatory procedures while placing pressure on farmers to act in ways that compromise the environment. Furthermore, the typical corporate GE monocrop undoubtedly

increases pesticide use which has significant implications for biodiversity and ecosystem health. However, the worldview adopted plays a central role in deciding whether the corporatization of agriculture and its use of GE is in breach of environmental ethics, due to its influence on the degree to which certain values are included in decision making processes. Consequently, framing the above results within the contrasting worldviews of anthropocentrism, technocentrism, biocentrism and ecocentrism aids in understanding the controversy and how it might be overcome, together avoiding further breaches of environmental ethics. The following chapter discusses the results of the literature analysis within this framework.

Chapter 5 Discussion

5.1. Introduction

In this chapter I will discuss the results from the previous chapter within the framework of the contrasting worldviews of anthropocentrism, technocentrism, biocentrism and ecocentrism. The arguments for and against GE crops and the corporatization of agriculture are highly dependent on these worldviews as they describe how humans should be interacting with the environment: the degree to which human influence is acceptable and whether the human-environment relationship should be seen as one of active management or stewardship. This environmental ethics framework supports the research objectives through identifying the characteristics of corporations' perceptions of the environment which affect the decision making processes surrounding GE crops and their risk. Consequently, if the corporatization of agriculture and the corporate application of GE are found to breach environmental ethics, then identifying such characteristics in the form of a worldview aids in first understanding the perspectives and values that have led to such breaches while also clarifying what changes need to occur in order to prevent further breaches. Within this framework, the significance of the results is discussed with regard to the research aim and objectives, while considering the contribution that the results make to the debate surrounding GE crops and the corporatization of agriculture.

5.2. Environmental Ethics of GE

The concepts of integrity, ability to flourish, ecosystem health and biodiversity are strongly influenced by the worldview held. Anthropocentrists and technocentrists are less likely than biocentrists and ecocentrists to value such concepts, as a result of not attributing them intrinsic value (eg. Heink et al., 2012). For example, GE technology compromises the biological integrity of the individual plant through introducing foreign genes in a way which would not occur through natural breeding processes. This breaches biocentric and ecocentric environmental ethics but is of no concern to those of anthropocentrist or technocentrist perspectives. Instead, technocentrists in particular are undoubtedly expected to be strong advocates of GE technology for its technological ingenuity and promise for innovative ways to harness environmental resources.

While the protection of the environment, its ecosystems and biodiversity can be justified from an anthropocentric perspective due to the valuable resources that it provides for humans (Myhr, 2010b), such justification will only exist in the presence of resources with identified human utility. From the perspective of an anthropocentrist or technocentrist, being inherently

reductionist, biological integrity and the ability to flourish are of little value to humans if the species involved provide no obvious or recognized utility. It would only be the intrinsic value attributed by biocentrists and ecocentrists together with the holistic appreciation of ecosystems which would consider the concepts worthy of attention. For example, media attention has ensured that the general public is being made aware of the implications for biodiversity, and hence humanity, if pollinators are compromised by pesticide use. However, insects with no obviously apparent benefit to humans do not receive the same respect, while they will undoubtedly be filling an essential niche within the ecosystem as a whole. This example highlights the danger of having inherently reductionist worldviews governing the decision processes surrounding GE crops, as the unpredictable consequences of the technology can be far-reaching and have unforeseen impacts on unlikely areas of the environment.

Furthermore, justifications from biocentrists and ecocentrists that demand a greater respect for biological integrity and ecosystem health are more controversial as they typically require a degree of compromise or inconvenience with regard to human utility or comfort (Myhr, 2010b; Thompson & Barton, 1994). Biocentrists and ecocentrists will be more willing to tolerate the discomfort associated with such inconveniences and be more willing to accept restrictions in accumulation of material wealth than anthropocentrists (Thompson & Barton, 1994) and technocentrists. With regard to agriculture, such inconveniences could surround the increased effort associated with farming practices that are less reliant on chemical inputs than GE monocrops. While supporters of traditional agriculture might argue that the effort is negligible in the long term, as GE seeds have been marketed as creating increased yield for decreased labour, an argument hard to beat for those who don't hold the environmental values of biocentrists and ecocentrists. For a corporation motivated by shareholder profit, a biocentrist or ecocentrist perspective could be perceived as compromising such profit and hence be even harder to justify.

5.3. Environmental Ethics of Corporatization

The corporatization of agriculture is vulnerable to the same variable allocation of values as GE. The corporatization of agriculture itself together with the use of pesticides, the monopoly held by agrochemical corporations and the IPRs that they own are perceived differently depending on the worldview held. For example, anthropocentrists and technocentrists who are preoccupied with technological innovation at the expense of traditional agricultural practices are less likely to see IPRs as breaching environmental ethics, as they are more likely to be convinced of the positive influence that IPRs have on innovation and less likely to

recognize the disadvantages of the replacement of traditional agricultural practices with corporate monocrops. Similarly, anthropocentrists and technocentrists are likely to be less concerned by the monopolies held by agrochemical corporations as they are less likely to perceive corporate environmental practice as unethical and hence see no reason to restrict it.

The corporate agriculture regime's heavy reliance on synthetic chemical inputs highlights the lack of biocentric and ecocentric values, and the presence of the inherent dualism as noted in the previous chapter. Such dualism results from the disconnect between humans and the environment, characteristic of anthropocentric and technocentric worldviews, and fails to recognize that such widespread use of pesticides and fertilizers have deep rooted consequences for the environmental systems of which humans and agriculture are just one part. This perspective was demonstrated clearly by the corporate message in the previous chapter that the purpose of pesticides is to 'clean' a farmer's field. This perception encourages the message that all species other than the crop itself are pests and therefore need to be eradicated, failing to recognize the essential role that all species play in supporting their ecosystems. While some species undoubtedly provide challenges for farmers, traditional and organic agriculture have already implemented less invasive pest management strategies that do not require such synthetic pesticides, making their use an unnecessary gamble on the health of the environment. Furthermore, the lack of holistic biocentric and ecocentric values of corporations could be blamed for the rise of herbicide resistant weeds and the ever increasing applications of pesticide that are resulting. Where short term shareholder profit takes priority over long term environmental sustainability, the increased applications of pesticides in response to herbicide resistant weeds will not be given the appropriate attention under an anthropocentric and technocentric world view.

Finally, by clarifying the link between a technocentric worldview and a likelihood of favouring GE technology, together with the typically anthropocentric and technocentric worldviews of corporations, the conclusion could be drawn that such an emphasis on GE crops in agriculture may not have occurred were it not for the corporatization of agriculture. It is highly likely that if the agricultural industry was not so heavily corporatized and profit focussed, the drive for GE innovation would have been slower and ultimately focused on crops with immediate environmental benefits as opposed to the cash crops that have eventuated from RR and Bt varieties. This is significant given the role that GE played in allowing for the corporatization of agriculture in the first place.

5.4. Risk Assessment

Just as with the ethics of corporatization and GE, the worldviews held strongly influence how risk, harm, and consequently the adequacy of risk assessment are perceived. The baseline of comparison, as described by Myhr (2010b) in the previous chapter, is a significant factor in assessing risk and is similarly influenced by worldview. For example, an ecocentrist would be more likely to use organic agriculture as the baseline of comparison due to the respect that it implies for the environment which is in parallel with ecocentric values. In contrast, an anthropocentrist might be more inclined to use non-GE industrial agriculture as the baseline of comparison. However, these two scenarios would attribute significantly different degrees of risk to the application of GE crops, as a baseline of organic agriculture represents a greater leap to GE agriculture than a non-GE industrial model. Consequently, the reliability of a risk-benefit analysis can be grossly distorted depending on the worldview held, due to such varying perceptions of risk and damage. Anthropocentrists will focus on the benefits to be had from GE crops while not paying adequate attention to the environmental risks while ecocentrists may underplay the human benefits in light of the much greater perception of environmental risk. Consequently, risk assessment processes conducted by corporations that do not include biocentric or ecocentric values will be unlikely to take into account the true extent of environmental risk that only a holist perspective could provide, but an exclusively ecocentric perspective may exclude the potential for genuine benefits such as drought tolerant crops (if these were a likely application of GE).

Technocentrism raises further doubts as to the appropriateness of corporate worldviews for risk assessment due to its rejection of the precautionary principle. The technocentric paradigm rejects the precautionary principle through arguing that “in the absence of full certainty, costly measures to prevent potentially serious or irreversible harm should be postponed for the sake of cost/benefit efficiency... [Technocentrists believe that] humans are sufficiently wise and far-seeing to manage any technology {e.g., nuclear energy, genetic engineering or nanotechnology) safely and free of corruption” (Gladwin et al., 1995, p.884). In contrast, the biocentric paradigm supports the precautionary principle, as described by Attfield (2012, p.86): “The agents in question should take into account the full foreseeable range of impacts, and not only those they intend”, arguably a more appropriate approach for assessing GE crops.

5.5. CSR

All four worldviews have significant implications for the effectiveness of CSR initiatives.

Bazin (2009) together with Purser et al. (1995) note the importance of understanding CSR from biocentric and ecocentric perspectives, respectively, as opposed to anthropocentric. For example, Monsanto's SHP was a CSR initiative supposedly aimed at resource poor farmers in a developing country; aside from the degree to which the program was inappropriate from a social perspective, no environmental provisions were included. Whether or not the farmers involved in the program experienced economic benefits as a result of participation is irrelevant given the inappropriate environmental application of the program. For example, to promote the application of corporate crops that were developed in a lab in a different country, in regions with unique and specific topographic, climatic and soil quality conditions, is irresponsible. The yield advantages that were to be experienced purely as a result of pest resistance did not take into account any of these environmental variables, yet again demonstrating a reductive perspective which according to Shiva (2015) had disastrous consequences for Indian farmers and local water resources.

5.5. Summary

This chapter demonstrates that the disparities in values between environmentalists and corporations can be accurately and effectively described by the contrasting worldviews of anthropocentrism, technocentrism, biocentrism and ecocentrism. These findings are valuable to the extent that they highlight the bias on both sides of the argument and the need for a degree of compromise to be found through the inclusion of the values contained within biocentric and ecocentric paradigms. When framed within these paradigms, the results of the previous chapter show clearly that anthropocentric and technocentric values are inadequate in avoiding environmental damage as a result of GE crops and their corporate application. Furthermore, the results show the importance of recognizing the role that GE has played as a tool in aiding the corporatization of agriculture. This is significant, as the corporate control of agriculture clearly breaches environmental ethics. Consequently, whether or not GE by itself breaches environmental ethics, if its role in corporatization is widely recognized then risk assessment and regulatory processes may better be able to take into account the corporate agenda.

Chapter 6 Conclusion

6.1. Introduction

This thesis aimed to ascertain whether crop GE and the corporatization of agriculture are in breach of environmental ethics according to the worldviews of biocentrism and ecocentrism within recent literature. As expected, the dominant worldviews of those critical of GE and corporatization were found to be in line with biocentric and ecocentric values, while those in favour of GE and unconcerned by corporatization were typically of anthropocentric and technocentric perspectives. Due to the different values employed by each, the two sides exhibit vastly different perspectives on whether environmental ethics are breached by GE and/or the corporate application of GE, and if so, to what degree. Biocentrists and ecocentrists perceive significant breaches while anthropocentrists and technocentrists perceive minimal, if any, breaches. The corporate priority of shareholder profit leaves little room for the inclusion of ecocentric and biocentric values in decision making processes surrounding the innovation and application of GE crops, specifically with regard to risk assessment. This results in compromises to biodiversity, ecosystem health, the ability of plants and ecosystems to flourish, and the integrity of plants and ecosystems. Consequently, the corporate application of GE is undeniably in breach of environmental ethics as described by biocentrism and ecocentrism. This thesis concludes that unless corporations are able to include the values of biocentric and ecocentric worldviews, the corporate control of agriculture and application of GE will continue to unavoidably breach environmental ethics with consequences for environmental sustainability, food security and climate change.

6.2. Main Findings

The research objectives of this thesis were to:

1. Establish the level of environmental risk associated with GE crops through identifying the concerns raised.

2. Establish the implications of crop GE for the environment and the consequent implications for environmental ethics as a result of such risk.

3. Establish the degree to which agriculture has been corporatized and the implications of such corporatization on the environment, significantly, through the corporate application of GE and compromises to the risk assessment process.

4. Establish the degree to which corporatization and the corporate application of GE can be explained by the world views of anthropocentrism and technocentrism, the benefits to be had from incorporating biocentric and ecocentric values, and the likelihood of such inclusion.

The concepts that were identified in Chapter 1 as having room for greater clarity in the literature were:

1. The consideration of the environmental effects of GE technology in isolation from the socioeconomic/socioethical implications;
2. The consideration of the corporatization of agriculture in isolation from GE technology;
3. The consequent consideration of the corporate application of GE in isolation from GE technology itself;
4. The recognition of GE in serving as a tool for the increased corporatization of agriculture;
5. The explicit link between technocentrism and a pro-GE sentiment.

Consequently, in response to the research objectives and the room for additional clarity in the literature, this thesis concludes that:

1. The level of environmental risk associated with GE crops is substantial and unnecessary given the alternatives available. Such risk and environmental implications in isolation from social considerations are substantial enough to warrant a change in application of the technology;
2. The implications of GE crops for the environment centre around the unpredictable and uncontrollable nature of GE technology, resulting in negative implications for biodiversity, ecosystem health, resilience and the ability of plants and ecosystems to flourish;
3. The degree to which agriculture has been corporatized is substantial. Multinational corporations hold sizeable monopolies over the industry resulting in the corporate application of GE being dominated by cash crops and a high reliance on pesticides and water. The environmental effects of the corporatization of agriculture in isolation from GE are significant enough to warrant a change in regulatory procedures and risk assessment practices.
4. The values of corporations are directly in line with anthropocentric and technocentric worldviews. The resultant lack of biocentric and ecocentric values result in breaches of environmental ethics. The inclusion of such values is necessary in order to avoid such breaches, but is also unlikely given the corporate agenda of shareholder profit.
5. Consequently, the most reasonable solution to the controversy is a situation of coexistence whereby corporations relinquish the extent of their monopoly on the agriculture industry in order to allow a balanced supply of open source, non-GE alternative seeds.

6.3. Moving Forward

Despite the polarity of the controversy and unlikelihood of corporations incorporating biocentric and ecocentric values, it seems that there is some middle ground to be found and there is significant hope for alternatives to GE that are not merely an anti-GE or pro-organic bias. While Waters and Pajerowska-Mukhtar (2012) appear generally in favour of GE for its potential to counter the growing challenges presented by climate change and population growth, they conclude that further research is needed to ensure that its introduction does not result in upsetting the natural balance of ecosystems and that solutions to such challenges likely do not lie in a reliance on GE alone, but a combination of GE and sustainable permaculture. Similarly, others battle for an amiable coexistence of GE and organic agriculture (Hubbard & Hassanein, 2013), and open source seeds and genetic material (Kloppenburg, 2010; Lemmens, 2014). Guehlstorf (2008) provides a critical perspective often omitted from either camp. A farmer of GE crops himself, he argues that he falls somewhere in the middle of the controversy, as it is in his best interests and responsibility to weigh up the environmental risk versus potential economic gain. Finally, the Union of Concerned Scientists (UCS) (2013) has produced a Policy Brief based on extensive research that proposes solutions to food security and environmental degradation through their "Healthy Farm" vision. The UCS (2013) state that American agriculture has reached a point where it must acknowledge that the industrial agriculture model is out-dated and compromising the health of humans and the environment, and needs overhauling in order to focus on the regeneration of soil, water and biodiversity (USC, 2013). Consequently, while this thesis concludes that current corporate agricultural practices and GE are in breach of environmental ethics, it is recognized that the corporate agenda leaves little room for compromise, so the most likely solution will be one of coexistence.

However, as one of the key findings of this thesis has been that the corporate application of GE is more of an issue than GE itself with regard to breaches of environmental ethics, it is worth noting that alternative applications of GE crops could significantly reduce any breaches in environmental ethics. For example, the first step would be the development of GE seed varieties by the public sector which genuinely increase intrinsic yield as opposed to merely operational yield, counter abiotic stresses such as water scarcity, while not being dependent on increased chemical inputs. Secondly, such public sector innovations would remain unpatented in order to allow resource poor farmers to save their seeds and ensure food sovereignty and economic security. Thirdly, such varieties could be planted using traditional mixed agriculture or permaculture methods, reducing or eliminating the need for pest management, synthetic fertilizers and tilling. Such methods would support biodiversity

both on and off farm, reduce soil, water and air pollution, and allow for coexistence with non-GE crops. These suggestions would not counter the dangers of genetic contamination of non-GE crops or wild plant populations. However, they represent a hypothetical scenario whereby the safety of transgenes are assumed, and corporate influence could be removed, demonstrating the extent of the role that the corporatization of agriculture has had on applications of GE crops.

6.4. Assumptions

Certain assumptions have been present through this thesis which affect the validity of the results and hence should be identified. Heink et al. (2012, p.9) note the importance of the assumption that "that biological diversity enhances ecological stability", a concept that was central to Leopold's (1949) *Land Ethic* and which affects the argument of this thesis. The conservation of biodiversity is central to the argument in favour of biocentric and ecocentric environmental ethics as it forms the strongest argument against the use of GE crops and the corporatization of agriculture. Thus, if one is of the assumption that biodiversity is not of significant value to ecosystem health then the argument that corporate decision making processes must include biocentric and ecocentric values is weakened.

There is also an underlying premise within the thesis that treats corporations as entities with the capacity to speak and make decisions, and thus acting as a person. This is valid in the sense that corporations have the legal status of a person, and that in order to understand the value systems that contribute to corporate decision making, the corporation must be understood as a "moral entity with intention" (Foster, 2010, p.98).

Finally, as is made clear throughout the thesis, in order to consider the environmental ethics of GE crops separately from the corporatization of agriculture, at different times, each required the assumption of being morally permissible in order to consider the true impact of the other.

6.5. Recommendations for Further Research

Further research is needed with regard to the role of neoliberalism and corporate-government relations. For example, there is significant mention in the literature of the risk assessment and regulatory process being compromised by such relations. The role of the government and neoliberalism was outside of the scope of this thesis though. However, it raises pertinent questions as to the necessary changes that need to occur for the appropriate inclusion of values in decision making processes surrounding corporate

agriculture and GE. If the corporate control of agriculture is to be reduced, the change will ultimately have to be instigated by the state-run regulatory agencies.

6.6. Conclusion

The results of this thesis highlighted that it is not GE technology in its own right that is causing the breaches in environmental ethics according to biocentric and ecocentric values as much as the corporate application of GE. Considering the environmental ethics of GE from the environmental ethics of corporatization separately, showed that while GE crops can be shown to violate environmental ethics to different degrees through the violation of the biological integrity of GE plants and genetic contamination through the escape of transgenes, the corporate agenda has resulted in the formation of large, unsustainable monocrops and a disproportionate commercialization of cashcrops (RR and Bt varieties) as opposed to varieties that genuinely increase intrinsic yield or counter abiotic stresses such as water scarcity. Such cash crops are more reliant on synthetic chemical inputs and increased irrigation, with significant implications for biodiversity, water and soil pollution. However, the corporate agenda and associated anthropocentric and technocentric values leave little room for the inclusion of the biocentric and ecocentric values which would avoid such breaches of ethics. Consequently, while the application of GE crops in any capacity is unnecessary due to the range of alternatives available, compromise can be found in reducing the degree of corporate influence and aiming for the cultivation of GE crops in a manner in line with traditional agriculture and a reduced dependence on chemical inputs.

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